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HYDRAULIC CALIBRATION

The department includes equipment for the volumetric calibration from overhead tanks, as well as circulating systems by centrifugal pumps through Venturi Meters. The hydraulic department handles all pipe sizes up to 24in. diameter and 150,000 gallons per hour maximum flow.

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KENT TECHNICAL RESOURCES

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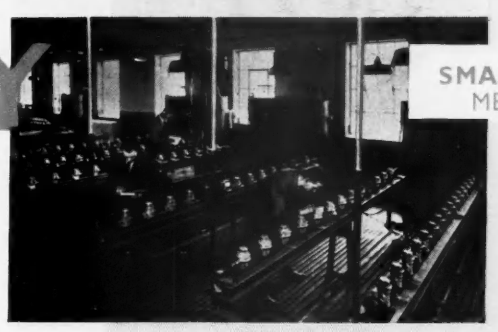
ELECTRICAL CALIBRATION

This department includes equipment for generating any current up to 750 volts D.C. and A.C. 3-phase up to 400 volts 24-60 cycles, single phase up to 1,000 volts 24-100 cycles. Up to 24 meters can be under electrical calibration at one time.



SMALL WATER METER TESTING

The photograph shows one of three such testing departments, having a capacity of 1,500 meters per week, tested against calibrated tanks, at all rates of flow, including a 112-hour test at one gallon per hour. No meter passed unless its accuracy at both low and high flows is within 2% of correct.

CALIBRATION OF FLOW METERS

The design and performance of Kent instruments are kept in the forefront by constant research and full-scale experiment, leading to continual developments and improvements.

Among the many Kent resources which contribute to the value of this work is the consistently accurate calibration equipment, without which George Kent's instruments could never have attained the standard of accuracy for which they have become world famous.

Kent calibration resources are exceptional; every meter is individually tested; there is no mass-calibration.

The pioneer work carried on in this country by Kent's in connection with Venturi meters, and the establishment of a complete range of Venturi throats with constant coefficients of the utmost technical value—was in a large measure made possible by the Kent calibration methods and equipment.

The importance of strict accuracy in the initial basis of reference has been shown by several incidents in Kent history, where the accuracy of Kent meters has thrown into relief the errors of calibration plant in the hands of users or testing authorities, errors which had hitherto passed unnoticed.

It is a tribute to Kent calibration methods that Kent meters are specified as the standard of reference for most of the important boiler trials.

George Kent Ltd. supply meters for accurate measurement of the flow of steam, water, gas, oil or any other flow, whatever the quantity or pressure; also equipment for controlling flow, temperature, pressure and level, and for the automatic control of boilers.

Kent's have made meters for fifty years and were the original British makers of the Venturi Meter as well as the pioneers of flow measurement by the orifice method.

Their works at Luton now employ over 1,000 men on the design and production of meters and controllers.

The illustrations show some of the Calibration Departments in the Works at Luton. In addition, Kent technical resources include a fully equipped Research Department as well as other calibrating and testing departments.

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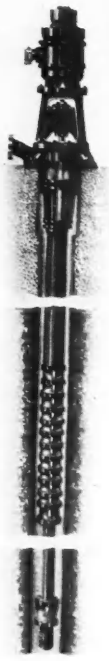

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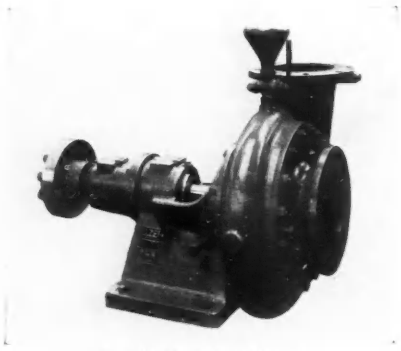
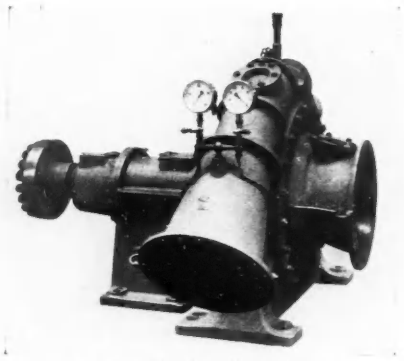


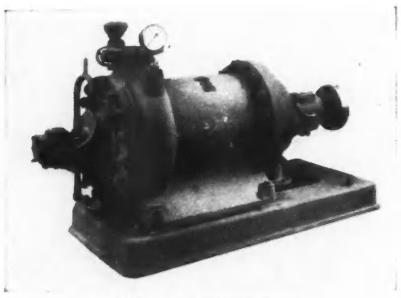
Lowlift Centrifugal Pump.



Medium lift Centrifugal Pump.

SULZER PUMPS

Axial flow Pump.



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A Seven-Day Journal

The French Steel Comptoir.

After five months' negotiation the Comptoir Sidérurgique de France, or French steel makers' sales organisation, was renewed for another period of five years at the meeting held in Paris on Saturday last. The difficulty in reaching a settlement arose out of the dissatisfaction of members over individual production quotas allotted for the home market at a time when business had fallen to so low an ebb that there was not enough orders to provide adequate employment to all of them. Discipline amongst members weakened until competitive selling threatened a collapse of prices and a disorganisation of the steel trade. The consequences of that state of things were so serious that the steel trade could only be saved from disaster by the strengthening of the Comptoir in a manner to ensure that, during the next period of five years, members would abide strictly by the terms of the agreement. No change has been made in the constitution of the Comptoir, but makers have pledged themselves to accept the decision of an arbitration committee of three members on all disputes affecting quotas that they cannot settle amongst themselves. The future of the Comptoir depends upon the faithful observance of that pledge. The dangers involved in a disorganisation of the French steel trade were so manifest during the past few months that makers see the necessity of perfect discipline for the maintenance of prices on the home market by means of restriction.

A New Fire-Testing Station.

On Tuesday, November 26th, the Duke of Kent officially opened the new fire-testing station of the Fire Offices' Committee at Boreham Wood, Elstree. The station consists of two separate buildings covering between them an area of 1¼ acres, the larger being the fire-testing building, whilst the other is devoted to fire-fighting appliances and administrative offices. The framework of the buildings is of reinforced concrete filled in with panels of "foamed-slag," a new form of concrete block. In the fire-testing building there are three types of gas-fired furnace for testing floors, walls, and columns. In the case of the floor furnace, the specimen is laid on top of a raised pit, and the load applied on top, the heat being applied underneath by means of a number of gas burners. In order to test walls according to specification, load must be applied, and to do this the specimen is placed under a ram capable of exerting a pressure up to 500 tons. The furnace, which comprises a bank of five batteries of twenty gas burners, is then wheeled against the specimen, heat and pressure to the required degree thus being obtained. Columns are tested in a similar manner to walls, the difference being in the furnace, which consists of two semi-circular banks of burners. The reason for having movable furnaces in the case of wall and column tests is that to complete a test to specification it is necessary to apply water to the specimen while it is still under load, and to do this the furnaces are run back from it on tracks and the hoses are then turned on. The whole of the floor of the building is served by a 30-ton electric overhead gantry crane. A raised control room on one side of the building, from which the entire floor is visible, contains the whole of the governing and recording mechanism for the building. The appliances building contains the chemical and electrical laboratory, rooms for sprinkler testing, water distribution valve testing and for the storage and display of sprinklers, valves and extinguishers.

A London Passenger Transport Bill.

In a Journal note of June 14th we outlined the new £35,000,000 London Transport scheme mentioned in the House of Commons by Mr. Neville Chamberlain, the Chancellor of the Exchequer. A Bill is being promoted by the London Passenger Transport Board and was deposited on November 27th in order to secure powers for the carrying out of the Board's section of the scheme. It is proposed to extend the Central London Line eastwards from Liverpool-street, its present terminus, to Stratford Station, and to build new lines in continuation of this extension between Stratford and Leyton; from Leyton the Central London line trains will run over the electrified L.N.E.R. tracks to Leytonstone; further new lines will be built between Leytonstone and Newbury Park *vid* North Ilford. It is further proposed to extend the Highgate line of the Morden-Edgware tube northwards to East Finchley, where it will join the London and North-Eastern Railway's Edgware-High Barnet lines, which will be electrified. Various improvements to stations, including new escalator installations, are to be made. The Board has already 48 miles of trollybus route in operation, and it has secured powers for the operation of a further 118 miles. In continuation of this programme, powers are being sought to establish trollybus operation on about 52 more miles of route. If these powers are granted there will be 218 miles of trollybus route, including 203 miles of converted tram route and 15 miles of new route. There will then be left 151 miles of tramway route, 20 miles of which will be operated by both trollybuses and trams. The routes in respect of which powers are to be sought run, in North London, from Waltham Cross and Enfield, from Barnet, from Parliament Hill Fields, and from Hampstead to in-town terminals at Moorgate, Smithfield, Farringdon-road or Holborn.

The Beama Dinner.

Under the chairmanship of Lord Derby, the President, the annual dinner of the British Electrical and Allied Manufacturers' Association was held at the Connaught Rooms, London, on Thursday, November 21st. Guests representing various interests were as numerous as ever. The toast "The Electrical Industry" was proposed by Sir Harry McGowan, chairman of Imperial Chemical Industries, and was acknowledged by Mr. V. Z. de Ferranti. "Our Guests" was proposed and seconded by Lieut.-Colonel R. K. Morcom and Sir Harold Hartley respectively, while Mr. J. A. Hirst, chairman of the Association, proposed "Our President." Sir Harry McGowan put forward suggestions regarding the depressed areas. In order that new industries, especially in depressed areas, should prove permanent economic assets, he explained, the cost of production must be low enough to enable them to hold their own against competition at home and abroad. Practically all previous efforts to develop new industries had proved fruitless, but the nation expected the Government to deal with the problem of the distressed areas promptly and energetically. The resources and *personnel* of the existing Development Councils were inadequate, and the grants made to them should be increased. The Government itself should be able to send to each area one or two men drawn from the British Civil Service and experienced in the knowledge of proposals likely to be acceptable to the Government, or, alternatively, skilled in the knowledge of difficulties to be avoided. Those men should make closer touch with the problems before them, and not continue to operate from Whitehall. Many industrial firms should be able and willing to lend qualified men to explore the specific possibilities of manufacture in the distressed areas. Money would have to be risked and the loss of some of it faced. A large industrial finance company in each area might be a suitable instrument, working with substantial resources raised publicly on a Government guarantee.

British Railway Policy.

In the course of a speech made by Sir Josiah Stamp at a luncheon arranged by the British Railway Stockholders' Association at Cannon-street Station Restaurant on Monday, November 25th, interesting reference was made to British policy with regard to new expenditure by the railways. Sir Josiah said that the cardinal principle in undertaking any new capital expenditure must always be the improvement or maintenance of net revenue. That principle was observed both from the point of view of the shareholders and the Railway Rates Tribunal. He confuted three erroneous notions which he said were current about railway boards—that they were merely passive agents of external policy with quite a subordinate regard to their own economic interests; that there must be no capital expenditure at all while certain stocks were being kept short of their dividends; and that any further capital for reconstruction was putting money in front of the ordinary shareholders. Sir Josiah said that the conditions under which the money for the Government scheme of extensions was proposed to be raised were much more favourable than the railways could obtain on their credit unaided at the present time. Speaking of his own company, he said that the L.M.S. Railway was carrying more passengers than ever in its history, and at much lower fares. On the freight side, considering the expansion of trade, by any index, since 1929, the amount received by the railways was disappointing. The percentages did not keep step; but the volume was not so disappointing. There was a constant wearing away of rates and the disintegration of classifications due to the enormous increase of traffic on the roads. The problem to find a right equilibrium between the railways and the roads was still before them.

Federation of British Industries Mission to Poland.

In a Journal note of October 11th we referred to the Federation of British Industries mission to Poland, which left London for Warsaw on Saturday, November 9th. The interests of the Federation were represented, it may be recalled, by Mr. Charles Ramsden, the foreign manager of the Federation, who was accompanied by Mr. D. H. Lyal, of the Department of Overseas Trade. The mission included representatives of many industries, such as the motor trade, the herring industry, textile machinery of various kinds, certain alloys, china clay, leather, the Sheffield industries, the Birmingham lock industry, internal combustion engines, and road machinery. Mr. Ramsden, who returned to this country last week, states that in the opinion of all the visit has been most successful, and that the progress made is hopeful for future trade relations. The Anglo-Polish Commercial Treaty, which was signed last February, has up to now produced good results. Statistics for the first nine months of this year appear to show an increase in United Kingdom exports to Poland of about 35 per cent. over the figures for the corresponding months of last year. The mission looked into certain difficulties that have arisen under the commercial treaty, chiefly the difficulty of getting sufficient licences for some classes of goods, and it received assurances of better treatment in the future. Several firms represented in the mission established new contacts, and nominated agents, and three or four firms secured, at any rate, opening orders, with which they expressed themselves as well satisfied.

The French Liner Normandie.

According to an interview of the Paris correspondent of the *Journal of Commerce* with Monsieur Henri Cangardel, the managing director of the Compagnie Générale Transatlantique, the further series of trials of the "Normandie" which have just been completed in the Bay of Biscay have confirmed the further model tests made on vibration and propeller problems, and have indicated the way in which these difficulties may be overcome. The trials were carried out during three days in consistently bad weather, and over a wide range of speeds and power conditions. The original three-bladed propellers were used, but instead of all the propellers turning outwards, the two wing propellers were made to turn inwards. Special instruments were used to measure the varying amplitude of local vibration in various parts of the ship and very exact data have been obtained, which, it is judged, will enable the vibration troubles to be overcome. In order to reduce further any cavitation and erosion, it seems probable that on resuming her service in March next the "Normandie" will be fitted with four-bladed propellers. The power trials showed, we understand, a certain amount of reserve speed. The winter lay-up of the "Normandie" was decided upon before the ship started on her maiden voyage, but it is thought that if the economic conditions continue to improve, then next year the liner will, in all probability, be in service for ten months in the year.

Port of London Annual Report.

The twenty-sixth annual report of the Port of London Authority, presenting the proceedings of the Authority for the year ended March 31st, 1935, has recently been published. At Surrey Commercial Docks additional accommodation has now been completed for cold storage at the Canadian Produce Warehouse East. Sheds have been erected at Station Yard, at Stave Yard, and at Swedish Yard. A transit shed has also been erected at the Greenland Dock. A contract has been placed for a new pair of locks for the Surrey entrance. New public road bridges at the Norway-Lady Dock passage and the Lavender Lock have been substantially completed. At India and Millwall docks, Blackwall entrance, a pair of lock gates has been extensively repaired, and an order has been placed for the renewal of the swing bridge over the Basin Passage. Parliamentary powers have been obtained to carry out a scheme for the modernisation of the Royal Victoria Dock. Important maintenance work undertaken includes flood prevention work at the Upper Docks, and extensive overhauling of lock gates, internal bridges, and quay cranes. The dredging of 1,833,302 cubic yards of material from the river and 1,289,206 cubic yards of mud from the docks was undertaken during the year.

Fuel Oil Burning Appliances.

During the last few days an interesting private exhibition of oil fuel burning appliances, brought together by the fuel oil department of Shell-Mex and B.P., Ltd., was on view at a Fuel Oil Supervisors' Conference at Shell-Mex House. We were invited to inspect the exhibition, which comprised over 150 exhibits covering oil storage, internal combustion engines, industrial, domestic, and central heating, and marine and rail transport. Attention was directed to the proper arrangement of oil fuel tanks and various valves and fittings were shown. Among the most interesting exhibits was a series of new automatic fuel oil burners. It showed that a rapid advance in British design has taken place during the last year or so. Originally most of the oil burners were of American design, but the new British burners lack nothing in design or finish, and in many cases automatic oil and air controls giving efficient combustion over a wide load range have been embodied in the design. The use of fuel oil for industrial processes continues to increase, and is being helped by the advances made by the appliance makers. Early in the year we recorded in these columns the formation of a coal-burning appliance association, and in this branch of the fuel industry progress has been recorded. It would seem to be to the interest of the fuel industry that technical co-operation should be encouraged between the makers of oil and coal-burning appliances so that the fullest scientific use of home-produced fuels may be more rapidly advanced.

Mechanical Flow Meters.

By Dr. F. V. A. E. ENGEL and R. J. WEY.

No. I.

Differential Manometers.

THE mechanical fluid flow meter of the inferential type was originated by Clemens Herschel nearly fifty years ago. He discovered the possibility of using a contraction of suitable shape in the pipe line to obtain a pressure difference which, in turn, is a measure of the fluid flowing through the conduit. In 1888 a British patent[1] was granted to Clemens Herschel relating to "Improvements in Apparatus for Indicating the Pressure of Head and Facilitating the Measurement of Liquids Flowing through Pipes or the like," giving a detailed description of both the Venturi tube and a mechanical flow meter. The contraction of the conduit, illustrated in Fig. 1, consists of a nozzle-shaped entrance section A, a parallel throat B with a number of tapping holes C arranged in a plane perpendicular to the axis of the tube and communicating with a pressure chamber D, and a divergent downstream section E. Herschel called this device a "Venturi tube" in honour of Giambatista Venturi,[2] who conducted experimental investigations on a similar arrangement of converging and diverging tubes. Venturi demonstrated for the first

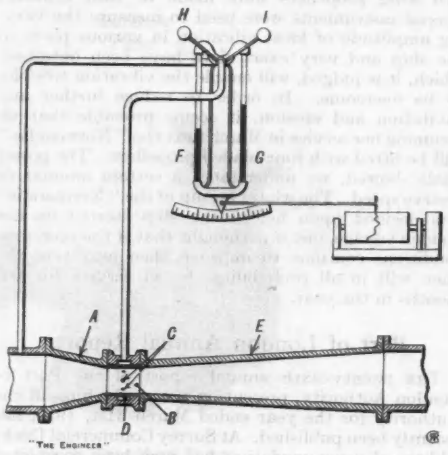


FIG. 1—CLEMENS HERSCHEL'S ORIGINAL FLOW METER—1888

time that there is a fall in static pressure in the contraction. The pressure drop or the differential head between the upstream tapping and the throat tapping is a function of the rate of flow. In addition to the Venturi tube, several other primary flow-measuring devices for closed conduits have been developed, the most important of these being the orifice plate, which has the merit of great simplicity. Well known, but less commonly used, are Pitot tubes and nozzles.

The rate of flow is proportional to the square root of the differential head, this relationship having a deciding influence on the design of flow meters. In most cases a linearly divided scale is required, particularly in connection with flow integrators, and therefore cams or other means have to be applied to transform the movement of the measuring mechanism into a linear deflection of the indicator, recorder, or integrator with respect to the rate of flow.

Three general classes of mechanical flow meters will be considered, viz.:—

(1) The differential manometer of the U-tube type;
(2) The floating bell;
(3) The hydrostatic balance.

Either one of these may form the basis of any mechanical meter, which may be further equipped with indicating, recording, and integrating devices.

Whilst indicators and recorders are of a more or less common pattern, and are very similar to those used in other types of instruments, for instance, electrical meters, a great deal of ingenuity and skill in the art of fine mechanics is shown in the design of the integrator devices, which will be dealt with at length in the last part of the article.

Parallel-limbed U-tube.

The differential pressure gauge most generally used at the present time is of the U-tube type, in which the vertical displacement of mercury (or other filling liquid) in two interconnected chambers balances the applied differential head. Referring to Fig. 2, it will be seen that the two chambers A and B are in communication through the tube C, and are sealed at the top by the covers D and E. The cover D carries the high-pressure connection, *i.e.*, that connected to the upstream tapping of the Venturi tube or other primary device, whilst the cover E carries the low-pressure connection communicating with the tappping at the throat of the Venturi tube.

With no differential head the mercury in the two limbs will be at the same level, indicated in Fig. 2 by the dotted line. The level of the mercury in limb A is measured by means of the float F, which transmits its motion by means of a rod G and lever H to a spindle I. This spindle passes through a pressure-tight bearing to the recording, indicating, or integrating devices.

The movement of the float under the action of an

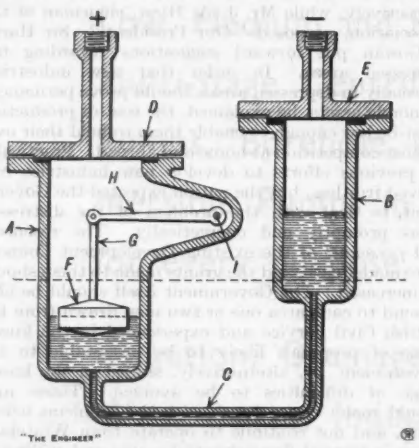


FIG. 2—PARALLEL-LIMBED U-TUBE FLOW METER

applied differential head will always be less than this head measured in terms of the filling liquid, and can be obtained from the following equation, which is derived from a consideration of the relative dimensions of the two limbs:—

$$t = \frac{h}{\frac{A_1}{A_2}+1} \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where t = movement of float,

t_{max} = maximum movement of float,

h = differential head,

A_1 = cross-sectional area of high-pressure limb,

A_2 = cross-sectional area of low-pressure limb,

A_3 = cross-sectional area of float.

In recent designs the low-pressure limb B is interchangeable to enable the same instrument to be used

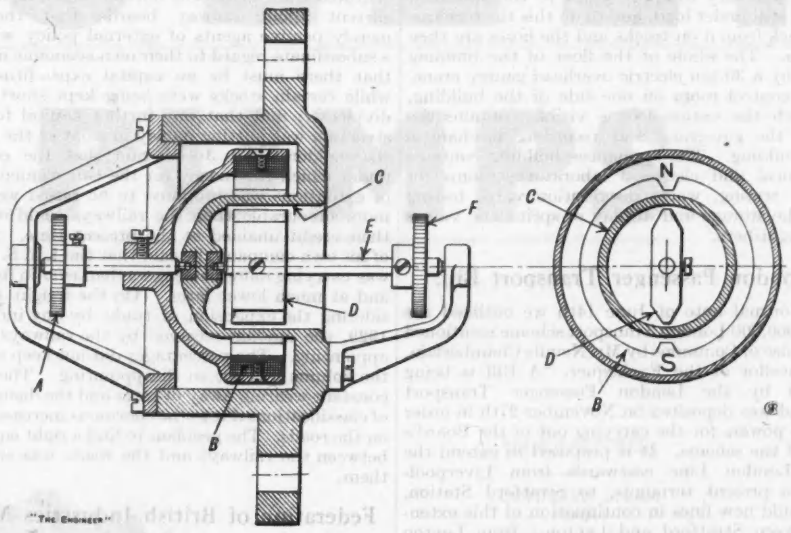


FIG. 3—MAGNETIC COUPLING

for different values of maximum differential head, the maximum float travel remaining constant.

The available working force per 1 per cent. of flow at maximum flow is proportional to the product of

$$2 \times k \, \frac{A_3 \times t_{max} \times \text{effective density of filling liquid}}{100}$$

The factor 2 occurs since 1 per cent. of flow corresponds to 2 per cent. of differential. The effective density is given by the difference in density of the filling liquid and the medium above this, *e.g.*, the effective density of mercury when used with air is 13·6 and when used under water is 12·6.

The factor k, which must be introduced to take into account the dimensions of the two mercury chambers, is given by

$$1 + \frac{A_3}{A_1 + A_2 - A_3}$$

In meters of normal design this factor will range from about 1·5 for low differential heads to about 3 for high differential heads.

A great advantage of this parallel-limbed manometer type of meter is that the quantity of filling liquid is not critical, since a reasonable amount of adjustment is obtained by moving the indicating or recording device relative to the spindle I.

Another means of transmitting the motion of the float through the meter wall is by means of a magnetic coupling, a typical design of which is shown in Fig. 3. A comparatively large angular deflection is desirable, and to obtain this the float is coupled by means of a rack to the pinion A, which is mounted on the same spindle as a circular two-pole permanent magnet system B. This magnet system rotates on the outside of a cylindrical partition C, which must be of a non-magnetic material and of sufficient strength to withstand the static pressure of the medium being measured. The armature D, which is mounted on the spindle E, rotates inside the partition C and follows the movement of the magnet system B. The recording and indicating devices are driven from the pinion F mounted on the spindle E. It is usually possible to transmit a torque of up to 100 gm.-cms. before disengaging the armature. Due to friction in the indicating and recording devices, some slip may occur in the coupling, but the effect of this may be made negligible by using a sufficiently large angular deflection for maximum flow. However, in this case it is possible for the coupling to engage incorrectly, *i.e.*, with 180 deg. lag or lead. It has been suggested that the armature be mounted excentrically, and that the poles of the magnet system be displaced to coincide.[3] With this arrangement the lag or lead is increased to 360 deg.

Shaped-limb U-tube.

In the differential manometer dealt with in the previous section, the movement of the float was proportional to the differential head, and therefore proportional to the square of the rate of flow. To obtain a linearly divided scale indicating the rate of flow, a cam or a similar device may be employed to transform the square law of the deflection of the meter spindle into the linear relationship between flow and deflection of the indicating device. Another comparatively simple solution of this problem consists in shaping the cross-section of one of the limbs to obtain a movement of the mercury level in the other limb, which is linear with respect to the rate of flow.

The general principle of a meter with a shaped limb of the U-tube type is illustrated in Fig. 4. Due to the square law, for equal increments of the rise of mercury level of 10 per cent. of the total float travel, the corresponding values of differential head are 1, 4, 9, 16, 25, 36, 49, 64, 81, and 100 per cent. of the maximum differential head for which the flow meter is to be designed. The cylindrical limb on the right-hand side of Fig. 4 is subdivided into ten sections of equal volume. The height of all the sections is equal and the top line of each section may represent the position of the mercury level for rates of flow of 10, 20, and 30, &c., per cent. of the maximum. The volume of mercury displaced from the left-hand or high-pressure limb is equal to the volume of the liquid rising in the right-hand limb. The height of Section 1 in the shaped limb which represents the first 10 per cent. of flow is very small, as the total differential head is only 1 per cent. of the maximum. On the other hand, for higher rates of flow, say, for the last 10 per cent. of the scale, *i.e.*, from 90 per cent. to the maximum, the increase in the differential head is 19 per cent. of

[1] British Patent Specification, No. 5738, 1888.

[2] J. B. Venturi, "Recherches Expérimentales sur le Principe de la Communication Latérale du Mouvement dans les Fluides," Paris, 1797. The importance of this work was soon recognised by his contemporaries, and English and German translations were published within two years.

[3] German Patent Specification, D.R.P. Nr. 581,370.

the total, which results in a comparatively long and narrow section 10. These considerations explain the shape of the limb, as illustrated in Fig. 4. With increasing rate of flow, the height of the cylindrical sections increases whilst the diameter decreases as the volume of the various sections is constant.

It has to be understood that the above-given illustration to obtain a linear movement of the float with respect to the rate of flow is only a method of approximation.[4] Strictly speaking, this relationship only holds for the finish of each section and results in an approximation within the range of each section. It is possible, however, to obtain a comparatively simple mathematical relationship for the correct shape of the cross-section of the limb, which will be dealt with in one of the subsequent sections.

Various designs of differential manometers have been developed. Fig. 5A shows a common type of U-tube with shaped limb. From the manufacturing point of view this design is fairly expensive, and has been replaced by designs in which a specially shaped displacer is mounted in either a cylindrical container or a conical container, as shown in Figs. 5B and 6 respectively.

Before concluding this section, a special feature has to be mentioned which is common to all the differential manometers which obtain a linearly divided scale by shaping a limb or the float. It is not possible to obtain a scale by the means given above, which is linearly divided over the total range of the instrument; the beginning of the scale will be unevenly divided.

Referring again to Fig. 4, the maximum differential head may be 10in. and the maximum rise of the mercury level in the low-pressure limb, say, 1in. The rise for 10 per cent. should be 0·1in., but the differential head for the first 10 per cent. of flow is

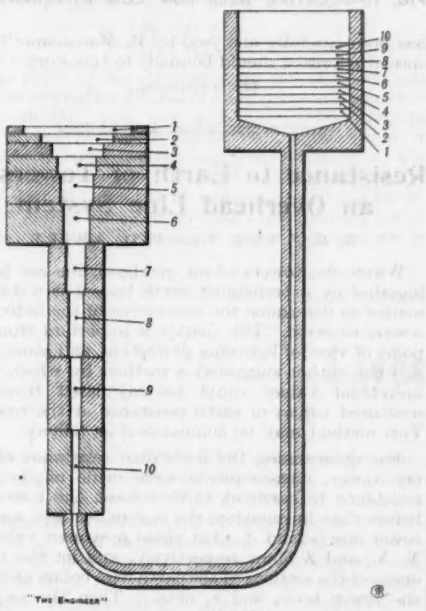


FIG. 4—SCHEMATIC ARRANGEMENT OF SHAPED-LIMB MANOMETER

itself only 0·1in. Therefore, assuming both sections to be of the same diameter, the mercury level will rise only half the amount of the differential head, *i.e.*, 0·05in. This results in an angular deflection of the pointer of the indicator of only half the amount of any of the following 10 per cent. sections.

The example given here is a very elementary one, but some more complete details will be given in the section which deals with the derivation of the mathematical relationships for specially shaped floats. The fact that the beginning of the scale of flow meters of the type in question does not correspond with the subdivision of the remaining section of the scale has an important bearing on the design of mechanical integrating devices, as will be seen from the last part of this article.

U-Tube with Shaped Float.

In the types so far dealt with the float, being in one of the limbs of the differential manometer and of cylindrical shape, repeats the position of the level of the filling liquid, whereas in the device under consideration, the float moves in a manner determined by the difference in level of the mercury in the two limbs and also by the shape of the float, this being such that a linear relationship between flow and travel is obtained.[5]

The special features of the design are illustrated in Fig. 7. The differential manometer consists of two concentrically arranged limbs which are formed by the container A and the tube B. The upper end of tube B communicates with the dome-shaped cover C. The filling liquid D is generally mercury and the space in the outer limb is the high-pressure section and is in communication with the Venturi tube or the orifice plate through the pipe E, whilst the inner limb communicates through C and the pipe connection F with the downstream or the low-pressure side of the differential device.

The float itself is of a special design and has two controlling parts, namely, one of cylindrical shape G and one of a special shape, as shown by H. Both these controlling parts are interconnected by a cross-piece I.

The principle of operation of this meter is as follows:—First of all it has to be noted that the mercury levels move under the action of the differential pressure as if there were no float present, provided

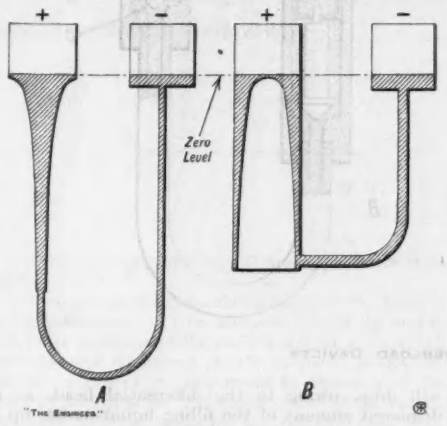


FIG. 5 (*A and B*)—TWO FORMS OF SHAPED-LIMB MANOMETER

that no frictional force acts on the float. The drop in level of the mercury in the high-pressure limb will cause a part of the float H to emerge, whilst the rise in level of the mercury in the low-pressure limb will immerse part of the cylindrical section of the float G. The dimensions are so chosen that the upthrust on the cylindrical part G due to the rise in mercury level in the low-pressure limb is greater than the downthrust due to the emerging of the shaped part H, caused by the fall in mercury level in the high-pressure limb. The float then rises until equilibrium is established once more. The dimensions of the parts G and H of the float assembly are obtained by a comparatively simple equation which will be given in a later section of this article.

One advantage of this type of meter is that the accuracy is independent of the quantity of filling

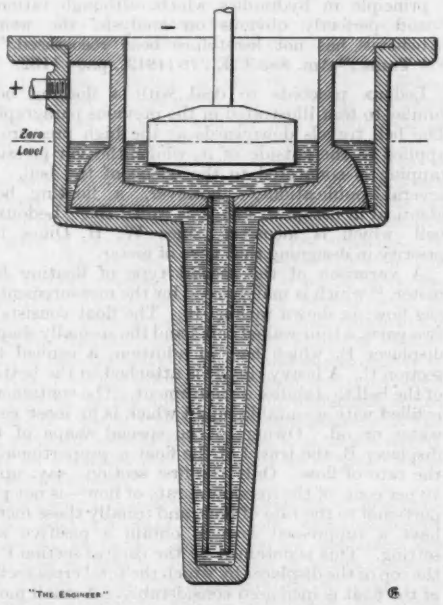


FIG. 6—CONCENTRIC ARRANGEMENT OF SHAPED-LIMB MANOMETER

liquid. Thus this quantity need not be carefully determined, as the zero adjustment can be used to compensate for differences in the initial level of the float. On the other hand, the weight of the float is very critical and must be carefully adjusted during calibration.

The design of this type of meter shows several other interesting features. The partition K between the low-pressure and high-pressure sides is specially shaped, the bottom part being slightly convex so that when water or steam is being measured all the air will accumulate in the top in order to escape into the upper part of the instrument when the equalising valve S is opened. The top of the partition plate K is concave so that if any mercury flows over the upper edge of the cylindrical tube B, owing to overloading of the instrument, it will accumulate in the concave portion. Opening the equalising valve will then allow the mercury to return to the high-pressure limb.

In general, all mechanical flow meters are fitted with overload devices, and a special design is shown in Fig. 7. On the top of the part of the float G is a rack N which operates the pinion M, which, in turn, rotates the main spindle of the mechanical indicating, recording, or integrating device. On the top of this rack is fitted a plate which has a valve face Q. When an overload occurs, the float will rise and press the face Q against the seating R, thus shutting off the communication of the connecting pipes E and F.

With this special type of overload valve, provided there is no accidental leakage, the instrument would not return from its maximum position once an overload occurs. The equalising valve S has then to be momentarily opened to release the overload device, and allow the float to assume its correct position.

It may be of interest to mention here in connection with overload devices two other designs which are in common use. Fig. 8A shows a special U-tube design which is in parallel with the actual measuring instrument, the tappings of the orifice plate or Venturi tube being connected to A_1 and A_2, and the flow meter to B_1 and B_2. It will be seen that the maximum differential pressure that can be applied to the overload device, and hence to the meter, is limited to that amount H which is necessary to cause the medium to bubble through the mercury contained in the U-tube, and, by suitably dimensioning this, the maximum differential pressure can be made any desired amount.

Another type of overload valve is shown in Fig. 8B,

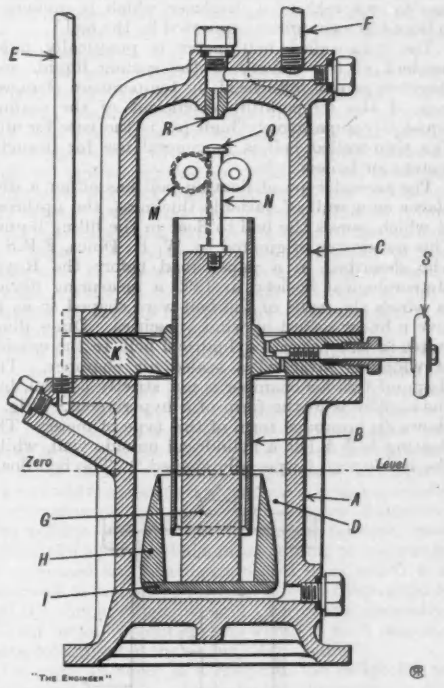


FIG. 7—SHAPED FLOAT TYPE METER

consisting of a float A and a conical valve B and seating C. If the mercury level drops below a certain point, the weight of the float which supports the conical valve presses this part against the seating and prevents further action of the pressure difference until normal conditions return. This type of overload valve is, therefore, quite different from the one previously described, as it is not necessary to open the equalising valve of the meter to get the instrument in normal working condition again. This has certain advantages, and consequently most of the commercial meters to-day are fitted with such an arrangement.

Floating Bells.

The use of the floating bell for the measurement of fluid flow is generally restricted to small differential heads. The filling liquid acts as a seal and the working force is obtained by the differential pressure acting on the top of the bell. The resulting movement is a function of the amount of the differential pressure, the dimensions and the design of the floating bell and the control forces. In the case of a thin-walled bell, the travel is almost unrestricted and can considerably exceed the amount of the differential head. This is not the case for meters based on the U-tube type, as only for one limb having an infinitely large dimension can the movement of a float in the other limb be equal to the differential head. In practice, however, the travel of the float of a U-tube meter is only a fraction of the differential head (see Equation 1). For this reason the floating bell is specially adapted for small differentials.

There are two types of floating bell meters to be considered. The first type is characterised by the fact that the wall thickness of the bell is almost

[4] If the walls of the sections have a suitable contour instead of being straight, it is possible to obtain an accurate scale shape. This method is described in German Patent Specification D.R.P. Nr. 579,780. Since the sections are relatively short, the contour can be easily machined, thus resulting in reduced manufacturing costs.

[5] For complete information, reference should be made to British Patent Specifications No. 327,065 and No. 398,558.

negligible, and when rising out of the liquid, there is practically no change in the upthrust due to displacement. The travel of the bell, which is a measure of the rate of flow, has to be controlled by an external mechanical force; for example, springs,

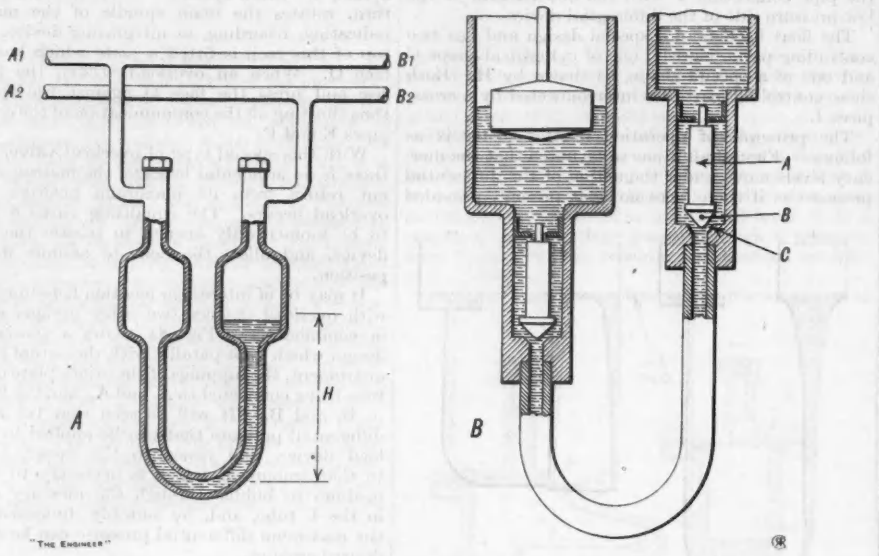


FIG. 8 (*A and B*)—OVERLOAD DEVICES

gravity control,[6] or a displacer which is immersed in liquid in a container supported by the bell.[7]

The thin-walled bell meter is practically independent of the density of the sealing liquid, and therefore is not influenced by temperature changes, even if the temperature coefficient of the sealing liquid is comparatively high (as is the case for oil). The thin-walled bell is in general use for draught meters for boilers.

The second type of floating bell has either a displacer or a wall of variable thickness, the upthrust of which causes the bell to float in the filling liquid. This meter was originated by W. H. Dines, F.R.S.,[8] who described in a paper read before the Royal Meteorological Society in 1892 a measuring device in which the walls of the bell were shaped so as to give a linear record of wind velocities. Dines illustrates in this paper a cylindrical bell, to the outside of which is attached a sealed air chamber. The shape of this air chamber is not strictly conical, but the surface is in the form of a hyperboloid.[9] Fig. 9 shows an improved form of this type of meter. The floating bell A has a cylindrical outside wall, whilst the inside wall is specially shaped.[10] The bell floats

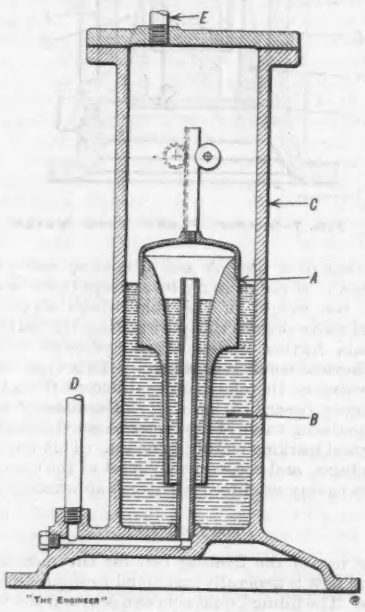


FIG. 9—DINES' FLOATING BELL METER

freely in the filling liquid B, which may be mercury, and which is in the sealed container C. The high-pressure connection D and the low-pressure connection E lead to the inside and the outside of the bell respectively. If there are no external forces (*e.g.*, frictional force or adhesion of the filling liquid) acting on the bell, the outside level of the filling liquid remains unaltered, and only the inside level will drop, owing to the differential head, as the displaced amount of the filling liquid makes up for the decrease in volume of the immersed part of the bell. The bell will travel until equilibrium of the different forces acting on it is restored. These forces are made up of the pressure on the top of the bell, which is proportional to the differential head, and the change in the upthrust due to the immersion of the bell and fall of the inside liquid level.

It is of particular interest to note that twenty years later, the same type of meter was reinvented and dealt with in a paper by J. W. Ledoux.[11] The section in which Ledoux described the floating bell meter starts as follows:—

> "The fundamental principles were discovered by the writer in 1904 and were finally developed into the best practical working form in 1909. The basic idea is a float shaped so that when acted on by the head due to the velocity of flowing liquid its movement will be directly proportional to that velocity.
>
> "The device is novel in form, and covers a principle in hydraulics which, although rational and perfectly obvious on analysis, the writer believes has not heretofore been recognised."—"Trans.," Am. Soc. C.E., 76 (1913), page 1152.

Ledoux proceeds to deal with a floating bell, similar to that illustrated in the previous paragraphs. The bell travels downwards as the high pressure is applied to the outside of it, whilst the low-pressure tapping is connected to the inside of the bell. In several publications,[12] however, a floating bell, identical in design to Fig. 9, is called the "Ledoux" bell, which is incorrect, since W. H. Dines has priority in designing that type of meter.

A variation of the second type of floating bell meter,[13] which is mainly used for the measurement of gas flow, is shown in Fig. 10. The float consists of two parts, a thin-walled bell A and the specially shaped displacer B, which has, in addition, a conical top section C. A heavy ring D is attached to the bottom of the bell to stabilise its movement. The container E is filled with a suitable liquid which is in most cases water or oil. Owing to the special shape of the displacer B, the travel of the float is proportional to the rate of flow. Only the first section—say, up to 10 per cent. of the maximum rate of flow—is not proportional to the rate of flow, and usually these meters have a suppressed zero to obtain a positive zero setting. This is obtained by the conical section C on the top of the displacer by which the total cross section of the float is increased considerably. A small movement of the float results in a comparatively large displacement of the filling liquid, which gives satisfactory working forces, even close to the zero of the instrument.

The accuracy of the meter as illustrated in Fig. 10 is dependent on constancy of the density of the filling liquid. Water has a comparatively small temperature coefficient, but is not suitable for installations in which the outside temperature may drop below freezing point. For such conditions oil has to be used, which, however, has a considerable temperature coefficient, and this seriously influences the accuracy of the meter readings. The influence of the temperature coefficient on floating bells with the specially shaped float

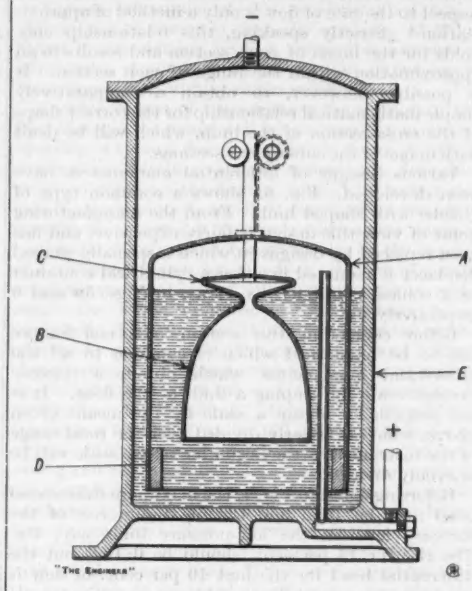


FIG. 10—FLOATING BELL FOR LOW DIFFERENTIALS

has been carefully analysed by R. Moissonnier[14] and special reference should be made to this work.

(*To be continued.*)

Resistance to Earth of Towers of an Overhead Line System.

By G. F. TAGG, B.Sc., Ph.D., A.M.I.E.E.

WHEN the towers of an overhead line are linked together by a permanent earth line, it is a difficult matter to determine the resistances of the individual towers to earth. This matter is important from the point of view of lightning protection, and some while ago the author suggested a method by which these individual values could be calculated from the measured values of earth resistance at the towers.* This method may be summarised as follows:—

For determining the individual resistance of any one tower, measurements were made of the total resistance to earth at three towers, the tower one before that in question, the one under test, and the tower one behind it. Let these measured values be X, Y, and Z ohms respectively, and let the resistances of the sections of the earth wire before and after the tower be r_1 and r_2 ohms. Then the required resistance to earth R of the tower is given by

$$R=\frac{Q\,(M+r_1)}{M+r_1-Q} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where

$$M=\frac{r_1\,(2\,X-r_1+\sqrt{r_1^2+4\,X\,Y})}{2\,(r_1-X+Y)} \quad . \quad . \quad (2)$$

and

$$Q=\frac{r_2\,(2\,Y-r_2+\sqrt{r_2^2+4\,Y\,Z})}{2\,(r_2-Y+Z)} \quad . \quad . \quad (3)$$

Now, owing to the nature of the problem, X, Y, and Z are not likely to differ greatly from one another, and the denominator of the expression for M contains the difference (Y−X), and that of the expression for Q contains (Z−Y). Any instrumental or observational errors may therefore be very considerably magnified, producing a resulting error which may be very serious. This constitutes a drawback to the method, as even with the greatest care in carrying out the actual measurements, observational errors may occur.

It is a fairly simple matter to check whether the errors are serious or not, and the method of checking is described below.

An overhead line system may be represented by a resistance network as in the diagram, where R_A, R_B, R_C, . . . represent the individual resistances to earth of the towers, and r_1, r_2, r_3 . . . represent the resistances of the sections of the earth wire between towers. If the tower under consideration is D, the measured value X will be obtained at tower C, the measured value Y at tower D, and the measured value Z at tower E. An application of equations (1)–(3) will then give the values of M_D, Q_D, and R_D. To understand the method of checking the results, it is necessary to realise what resistances are represented by M_D and Q_D. Consider M_D first.

If a line $p\,q$ is drawn across the network as shown,

[6] British Patent Specification No. 238,196, 1925, shows a double bell, the movement of which is gravity controlled. In this design an approximately linearly divided scale indicating flow of fluid is obtained.

[7] British Patent Specification No. 364,906, 1931.

[8] W. H. Dines, "Anemometer Comparisons," *Quarterly Journal*, Royal Meteorological Soc., London, Vol. XVIII, 1892, pages 165–183.

[9] "A Dictionary of Applied Physics," edited by Sir Richard Glazebrook, Vol. III, London, 1923, page 505. Fig. 17 on the same page shows the improved form of the Dines meter.

[10] British Patent Specification 27,332, 1910, shows a similar design, but the only claim is restricted to a constructional feature, which seems to prove that in 1910 the design of this type of flow meter was common knowledge.

[11] J. W. Ledoux, "A Mechanism for Metering and Recording the Flow of Fluids through Venturi Tubes, Orifices, or Conduits by Integrating the Velocity Head," "Transactions," Am. Soc. C.E., Vol. LXXVI, 1913, pages 1148–1171.

[12] "Fluid Meters: Description of Meters," Part II, Report of A.S.M.E. Special Research Committee on Fluid Meters, New York, 1931, page 28; and, further, G. Ruppel, "Tauchglocken-Manometer mit Mechanischer Radizierung für Durchflussmessung," Archiv für Technisches Messen, J., 1233–5, April, 1934.

[13] A meter similar to Fig. 10 is shown in British Patent Specification No. 993, 1911, in the patent drawings. Also a simple device is given which enables the travel of the float to be transmitted by means of a rod attached to the bell and passing through a sealed tube.

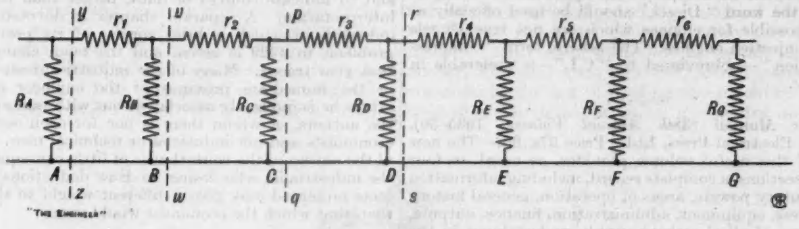
[14] R. Moissonnier, "Le Réglage des Débitmètres à Cloche Flottante," Chaleur et Industrie 7, 1926, pages 373–380.

* THE ENGINEER, 1933, Vol. 155, page 422.

M_D represents the total resistance of that part of the network to the left of this line measured at $p\,q$. Similarly for tower C, M_C represents the total resistance of that part of the network to the left of a line $v\,w$, measured at $v\,w$, and so on. The values of Q, M, and R can be calculated for each tower first by an application of equations (1)–(3). Now a consideration of the diagram shows that if M_C and r_2 are added together, and this combination placed in parallel with R_C, the result is M_D. Since R_C is supposed to have been calculated already,

$$M_D = \frac{R_C\,(M_C + r_2)}{R_C + M_C + r_2} \quad . \quad . \quad . \quad . \quad . \quad (4)$$

This gives an alternative method of calculating



M_D, and while a calculation from equation (1) involves two measured quantities, a calculation from equation (4) involves three, the values obtained at towers B, C, and D. One calculation therefore serves as a check on the other.

This can be carried a stage farther. If M_B and r_1 are added together in series, and this combination placed in parallel with R_B, the result is M_C. That is

$$M_C = \frac{R_B\,(M_B + r_1)}{R_B + M_B + r_1} \quad . \quad . \quad . \quad . \quad . \quad (5)$$

The value of M_C obtained from this equation can be substituted in equation (4), and gives a third calculation for M_D, and, moreover, one which involves four of the measured resistances. Similarly, it is possible to calculate M_D, using five or more of the measured resistances. If these various methods of calculating M_D give results which agree among themselves, it may be assumed that observational errors are not serious. If there is a wide disagreement, it will be necessary to repeat the measurements with greater accuracy, and it may be possible by examining the results of the various calculations to determine where the error lies. It will be noted that in checking the value of M for any one tower, it is necessary to work back towards the left-hand end of the network in the diagram.

A simpler method can be developed for checking the values of Q. Now Q_D represents the total resistance of that part of the network to the left of a line $r\,s$, measured at $r\,s$, and is therefore the same as M_E. Similarly, $Q_C = M_D$, $Q_B = M_C$, &c., so that in checking the values of M by the method described above, the values of Q are also checked. In fact, this equivalence between the M and Q values can be used immediately as a check as equations (1)–(3) are applied for each tower.

It is suggested that the checking could be done in the following way :—After the values of M, Q, and R have been determined for each tower in turn by an application of equations (1)–(3), a tower somewhat near the centre of the line could be chosen and the values of M and Q for this tower could be calculated in several different ways by the method described. If good agreement is obtained among the results, it may be assumed that observational errors are not serious. If such agreement is not obtained, it would be advisable to make check calculations at several other towers, to endeavour to correct these errors.

It will, of course, be appreciated that an accurate knowledge of the resistances of the sections of earth wire between the towers is essential, and that the greatest possible care is necessary in carrying out the actual earth resistance measurements at the towers.

Literature.

Limestone and its Products : Their Nature, Production, and Uses. By ALFRED B. SEARLE. London : Ernest Benn, Ltd. 1935. Price 42s.

MR. SEARLE is well known to engineers as a technologist of long experience and the author of a number of useful works relating to materials and products employed in the building and other industries, and in engineering constructions, and he deals with limestone and its products with his usual thoroughness and perspicacity, the fluency and forcefulness of his style and his command of language enhancing the value of descriptions of processes or procedure and of discussions of means and methods. As regards the importance of the subject and the extent to which the ground is already covered it may suffice to cite observations, in the author's preface, to the effect :—That limestone surpasses all other minerals in the number and diversity of its uses ; that no text-book has yet been written which deals with the subject as a whole ; and that while treatises on the origin and distribution of limestone contain some references to its uses, and a considerable amount of information on lime is scattered through numerous books and papers, many of these are not readily accessible.

To the mineralogical and geological aspects of the subject, Mr. Searle has accorded only a small, though adequate, space, the book having been written primarily for industrialists. It will be of service to four classes of readers—those concerned in the quarrying of limestone and in the burning and preparation of lime ; those using either material in industries ; engineers ; farmers, local authorities, and householders. Where implied by the context, the word "limestone" includes chalk, marls, and other minerals mainly consisting of carbonate of lime, or, rarely in so high a proportion, of carbonate of magnesia. Arranged in a manner convenient for reference, Chapter I relates to the occurrence, composition, and properties of those materials. Nomenclature is presented in respect of geology, mineralogy, descriptive names, and, with useful distinctions between strict and loose terminology, customary terms.

Of the twelve chapters of the book, one relates to the quarrying and mining of limestone, one to the preparation of the stone for various purposes or processes, and, not including a chapter on storing, packing and despatching, six to the burning and preparation of lime. A chapter is devoted to the various uses of limestone and other forms of calcium carbonate, and another, of 150 pages, to the multifarious uses of lime. Of interest to engineers are the passages relating, in the former, to building and to road construction ; in the latter, to both those classes of work and to the employment of lime in the softening and purification of water.

Since the subject of the work is objective in character, radiating, as it were, a number of subjects proper, the manner in which the author handles his theme may best be suggested by references to features of some of the chapters and by a few citations. In the first chapter, Mr. Searle shows himself as in line with investigators to the results of whose work the attention of engineers has recently been directed in respect of igneous, metamorphic, and sedimentary rocks, in that he stresses the significance of texture and the value of microscopical examination, especially in regard to the information which the microscope conveys as to the form in which impurities occur. Again, in view of the recent re-establishment of the old physical tests of road stones, it is worth noting that he considers the rattler test as of great value for that purpose.

The various operations conducted, the dispositions made, and the machines, tools, and equipment employed in mining and quarrying the stone are described in detail. In this and in other chapters the author gives due consideration to simple or primitive appliances and to significant, but often overlooked, details. The wide basis of his views in regard to economical dispositions or methods and his abiding sense of the importance of the human element, especially in regard to acquired skill and the development of instinctive judgment, render very interesting the chapters mainly based on his own experience. He observes that, in blasting operations, "... it is still a fact that better results will be attained by an experienced, intelligent quarryman working without any conscious adherence to rules than those which result from the efforts of less experienced men who follow rules closely." Rules are "... rough guides to general practice which ought not to be disregarded without reasons." Again, as regards lime burning : "The fact is that a really good lime burner works far more by instinct than by conscious application of knowledge, and herein lies his success. If he were to think too much about his work, and especially if he were to 'worry' about it unduly, his instincts would become subservient to his conscious thought and he would probably fail ignominiously." The failure, in other operations, of the instinctive intelligence, is recognised in a passage relating to shovelling, in which a detailed description is given of the movements which should be made in order to render the work easier for the men and more profitable for their employers.

In the chapter on quarrying, the author predicts "an enormous future" for wave transmission of power, as exemplified by Mr. G. Constaninesco's method, by means of which, he states, eight times as much power as that delivered by compressed air with the same input can be transmitted to drills at the rock face, the difference representing a saving of 70 (? 700) per cent. in power. In the chapter on the uses of lime, ten pages are devoted to its employment in agriculture—that is, in farming in the broadest aspect.

As regards natural cements, the author considers that the cost of installing means of testing and adjusting the proportions of the constituents of the raw materials is justified by the increased value of the product. His opinion will carry weight ; but there is something to be said for the view that limes which are always strong enough and sufficiently hydraulic for a considerable range of purposes are truly economical materials. The method of grading broken stone for maximum density, described on page 239, is open to criticism in respect of the omission of the additional weighing necessary in the case of a stone which absorbs a considerable proportion of the void-measuring water ; as also, perhaps, in that the added volume of smaller stone should be somewhat less than the volume of the water contained in the voids of the large stone.

In the excellent chapter on lime kilns there are, besides other useful illustrations showing dispositions, sixteen sectional drawings of vertical and two of horizontal kilns. These are fully described and the advantages and disadvantages, inherent or otherwise, of the different types of kilns and forms of accessories are considered in close detail. Lime burning, slaking, hydrating, and other processes are described, explained, and discussed with similar thoroughness and with unusually searching examination of points relating to efficiency or economy. Engineers who are concerned with the utilisation of "waste" gases may find it worth while to review their experience and data in the light of the matter, in Chapter IX, relating to the utilisation of kiln gases and to the manufacture and uses of carbon dioxide, while to the attention of users of limes Chapter X, on the manufacture of special forms of the material, may likewise be commended.

As a text-book on limestone and its products, and as a work of reference in respect of the many materials described and their numerous and diverse purposes, Mr. Searle's book will be welcomed in many quarters. Its value to technologists and industrialists will be, at least, considerable. In respect of the economy so often lacking in their dispositions as regards lay-out and the transport of materials, it may specially be recommended to owners and managers of quarries. The volume will also be of value to farmers, local authorities and householders, as tending to encourage an increased and intelligent use of lime, which is a deterrent to malignant growths in both the vegetable and the animal kingdoms, and a corrective, generally, of acid or foul conditions, its value in such respects being recognised in the saying "lime is life."

On page 13 there is a misprint too delightful to be missed. It is "carniferous limestone" for carboniferous.

The Lay-out of Small Water Mains. By H. H. HELLINS, M. Inst. C.E. London : Sir Isaac Pitman and Sons, Ltd. 1921, reprinted 1935. Price 7s. 6d.

ENGINEERS who are familiar with this handy aid to computations of pipe diameters and dispositions will be well content with a new edition in the form of a reprint, since the direct applications of theory to practice to which it relates are among those which are unaffected by technical developments. As indicated by the sub-title, the book presents "notes and tables dealing with various problems in simple, compound, double, and ring mains." It explains and exemplifies methods applicable to mains or parts of mains, or portion by portion, to whole systems of distribution. Such assistance is especially useful when a large number of pipes have to be changed or the extent to which costly substitutions may be avoided must be ascertained, under altered conditions of flow and head resulting from extensions rendered necessary by growth of population or expansion of the area served, and making the system hydraulically and economically wrong.

The author's procedure largely consists in finding what is the diameter of an equivalent simple main or portion of a main, for the existing disposition in that length ; while the process can be reversed, to provide a similar or another relatively complex disposition, in which the pipes are of the proper diameters.

In his application of the values of the fifth power of the diameter, the author divides by m, which he derives from a modification of Darcy's formula, in a range of values depending upon the diameter and condition of the pipe. Preceded by an explanation in general terms of the character of the computation, the mathematical demonstration is followed by one

or two examples. How far the user of the book is taken beyond the basic relations, and to what extent he is relieved of the trouble of devising particular applications, may best be indicated by brief mention of the problems and discussions in the text:—Discharge and head for a compound main in tandem; relative inclinations for the same flow, or relative heads for the same flow and length; the design of a compound main in tandem, for reduction of head; and to utilise a definite amount of spare head; discharge and head, also apportionment of flow, for simple and compound double mains and for simple and compound ring mains; equivalent length; cross connections; inclination and discharge. Attention is directed to some important considerations and to data relating to fire hydrants, and the text concludes with a brief discussion of velocity and velocity head. Seven tables, for use in the computations, are very conveniently displayed, each on the right-hand part of a folding page, so that the table may be laid open alongside the text to which it relates. There is also, for flows up to 4000 gallons per minute and for nineteen sizes of pipes up to 15in. diameter, an eight page table of the inclinations in feet of length per foot of head, while another table shows flows due to velocities of 1ft. to 12ft. per second, the corresponding velocity heads being also given.

The book is in all respects clearly printed, the types chosen being of adequate size and the lines well spaced, while the fifteen simple diagrams and one graph, which suffice for the author's purposes, are well drawn and reproduced. Mr. Hellins has clearly expressed and exemplified the simple and combined relations which govern the computations, and he has adequately supplied and conveniently marshalled the values of the governing expressions or deduced quantities. Accordingly, his book is one the employment of which must considerably facilitate the engineer's computations in the design or improvement of water supply systems, while it may especially be recommended as a guide to the draughtsman or computor entrusted with the working out in detail of pipe diameters.

Tools of To-morrow. By JONATHAN NORTON LEONARD. London: George Routledge and Sons, Ltd. 1935. Price 12s. 6d.

MR. NORTON LEONARD is an American, and he has a fluidity of speech on a diversity of subjects which is rarely found on this side of the Atlantic. Here one man, as a rule, speaks about one thing, but in America authors and public speakers do not hesitate to survey the whole field of human knowledge in a single breath. And they do it with surprising skill and accuracy. Mr. Norton Leonard does it with surprising skill and accuracy, but he leaves us panting for breath. He opens the dam upon his words and we are carried away by the flood. Not roughly, for his words and ideas flow in easy harmony: but he covers so much ground in so short a space and at such a high velocity that in the transit we gasp like the passenger in a high-speed car without a windscreen.

In a technical newspaper the title "Tools of To-morrow" may be misleading. The reader, seeing it in that *venue*, may expect it to refer to technical work on the approaching developments of workshop appliances. The book is nothing of the kind. The sub-title calls it "An Account of the Things Known to Science To-day that Must Change Our To-morrow." Again, it is little of the kind. True, there are accounts of the progress of a few scientific inventions and discoveries. But they do not make the true substance of the book. It is, in fact, a philosophical disquisition on the value to mankind of technological improvements and an attack on the folly of thinkers and rulers who cannot see how to make use of the amenities which science and technology offer with both hands. Mr. Norton Leonard does not offer to put them right; he just tells them they are wrong and leaves it at that.

There is plenty of good stuff in the book, and it is so pleasantly presented, with an occasional dash of spice, that you are carried forward by the cataract of words, feeling at the end exhausted indeed, but yet ready to admit that you have had a good time. With much that the author says we are in hearty agreement, and we stand in admiration of the skill with which he presents technical and economic questions to the general reader. We recommend engineers to leave this book about in places where those who rail against technical progress may come across it.

SHORT NOTICES.

Marine Engines. By G. L. Overton. Handbook of the Collections in the Science Museum, South Kensington. 1935. H.M. Stationery Office. Price 2s.—We need not have the least hesitation in saying that there is in the world no finer collection of models of steam engines than that of Marine Engines in South Kensington Museum. Many of them were made by very famous firms, and some have the stamp of the greatest model makers upon them. They are not only invaluable as an ocular guide to the rise of the steam marine engine, but the majority of them are as much works of art as the marvellous ship models which are to be seen in other galleries of the Museum. In the present handbook Mr. Overton has traced the history of the marine engine from Hull's proposal of 1736, through the steam turbine, up to the internal combustion engine, using the Science Museum collection for illustrations. As a consequence, the reciprocating steam engine occupies the largest single section of the handbook, the steam turbine comes second, and the internal combustion a poor third. It is to be hoped that some day a representative collection of models of marine oil engines may find its home in the Museum. There are many expert amateur model makers in this country of whom the majority spend their leisure upon small-scale locomotives. We would like to suggest to some of them that they should consider the production of marine internal combustion engines for the national collection. Mr. Overton's descriptive text is written, of course, for the general visitor to the Science Museum, and it therefore avoids detailed technology, but as far as we have examined it, it does give a just idea of the progress of the art with which it deals. May we, however, invite the author, when revision takes place, not to perpetuate the term "semi-Diesel"? It has now been dropped by engineers and was never one which could be accepted with approval. We suggest also that the word "Diesel" should be used officially as little as possible for engines which are not true Diesels but solid-injection engines. The generic term "compression ignition"—abbreviated to "C.I."—is preferable in every way.

Garcke's Manual (*38th Annual Volume*, 1935–36). London: Electrical Press, Ltd. Price 37s. 6d.—The new edition of this useful volume provides, as usual, in four classified sections, a complete record, including information as to statutory powers, areas of operation, general history and progress, equipment, administration, finance, outputs, profits, &c., of all electricity supply undertakings in the United Kingdom and throughout the British Empire. It also covers all electrified railways, tramways and trolley vehicle systems, telegraphs and telephones, electrical manufacturing companies, investment trusts, and allied concerns. Over 5000 undertakings are dealt with. The latest authentic information obtainable up to the time of going to press is included, even to the extent of an addenda section providing summaries of the new accounts received while the volume was being printed.

In response to numerous requests, the publishers have re-introduced the contractors' section, giving the names and addresses, arranged under towns, of over 6000 electrical contractors, including those of the national register and members of the Electrical Contractors' Association. The section serves the additional purpose of providing an index to the towns and principal villages in which electricity is available and gives the name of the supply undertaking, the voltage of supply, and information regarding showrooms and service faculties. The important data published for the first time in the previous edition of the volume, showing in respect of each undertaking the extent of the authorised area in acres, the population, number of premises in the area, and the rateable value, have, in common with the whole of the contents of the Manual, been thoroughly revised and brought up to date.

Finishing Metal Products. By H. R. Simonds. London: McGraw-Hill Publishing Company. 1935. Price 21s. net.—It is now recognised that an attractive finish is an important factor in the selling of metal products. This book deals with the various types of finish, such as galvanising, polishing, plating, lacquering, and painting. Many of the chapters have already appeared in a series of articles, "How Attractive Finish Helps Metal Products Sales," in our American contemporary *Iron Age*. These articles have been extended and much new material added. The various sections of the book deal with the commercial aspects of finish and appearance; preparation for the finish of metal products; polishing and buffing; plating and spray coating; painting; and a number of special finishes. Although some of the information given is quite familiar, those who are particularly concerned with metal finishing will find the volume of some interest and value, though in some respects it is not sufficiently thorough to be practically useful. We have looked in vain in it for more than a brief mention of the use of cellulose cracking paints now so largely used for the coating of instruments, cameras, and similar products. Is it possible that this now very popular finish in Europe is not in widespread use in America?

Industrial Electrons. By F. H. Gulliksen and E. H. Vedder. London: Chapman and Hall, Ltd. Price 17s. 6d.—Many applications of thermionic devices are described in this book, which also deals with thermionic tube characteristics and their fundamental circuits. It is shown that thermionic tubes of various kinds have many applications in industry apart from those that are generally known, and that all electronic tubes may be divided into three classes, viz., light sensitive, high vacuum, and gaseous tubes. The circuits of the three classes of tubes are discussed separately to indicate the various forms of control available. In some cases the control schemes described are highly ingenious and would be impossible without thermionic tubes; others might be carried out mechanically or by other electrical means, although more cheaply and effectively by the electronic method. It often happens, the authors explain, that there is a need for control based on transient conditions of such short duration that mechanical and electro-magnetic devices cannot be successfully applied and electronic control which is devoid of inertia is essential. Thermionic tubes are also shown to offer the important advantage of operating with very small currents an unlimited number of times without wear. Although the book is based on American practice, it can scarcely fail to appeal to all interested in the subject with which it deals.

Modern Radio Communication. By J. H. Rayner. Vol. II. London: Sir Isaac Pitman and Sons, Ltd. 1935. Price 7s. 6d.—The publication of this second volume on "Modern Radio Communication," written by Mr. J. H. Rayner, is largely attributable to the recent enlargement of the scope of the City and Guilds examination, covering the subject, and to the success of the author's original volume. Fundamental principles outlined in the first book have been amplified and additional information provided to throw light on those subjects which are not called for in the syllabus for the preliminary and intermediate grade examinations. An effort has been made to provide a thorough groundwork of fundamental ideas without the aid of mathematics. Detailed proofs of some of the more important statements are included and where possible every statement is explained. Particular care has been taken to familiarise the reader with the principles of feeders and feeder networks which have hitherto either been treated intensely mathematically or with a vagueness which has left the student mystified as to what really occurs.

Britain in Depression. London: Sir Isaac Pitman and Sons, Ltd., Parker-street, W.C.2. Price 10s. 6d. net.—This volume is the report of a committee, appointed by the Council of the British Association for the Advancement of Science to prepare a record of the affect of the world crisis on British industries. It is stated that the primary aim of the book is to record the principal events and to indicate sources of data, rather than to provide interpretation. A separate chapter is devoted to each industry, in which a brief survey of its position and problems in 1929 is given, and the main changes since that year traced. Many of the industries dealt with are in the immediate province of the engineer and with others he is indirectly associated, but with rare exceptions the authors, of whom there is one for each section, are economists and not industrial or technical men. In view of the nature of the work that is of little consequence, but the industrialist who desires to draw deductions from the facts presented may give a different weight to the details than that which the economist would give.

The Operation of Motor Ship Auxiliary Machinery. Volume 2. By J. Lamb, A.M.I. Mech. E. London: Charles Griffin and Co., Ltd. 1935. Price 12s. 6d. net.—Auxiliary machinery on board motor ships plays such an important part that the author has now written the second volume of this book produced for the benefit of those engineers who work extensively with this type of machinery. As in the previous volume, he has not dealt to any great extent with the theory of the various machines, but has gone to much trouble to explain clearly their construction, operation, and maintenance. The first volume covered auxiliary oil engines, air compressors, turbo-blowers, electric lighting, electric deck machinery, &c. This second volume deals with liquid fuel firing, waste heat recovery, reciprocating pumps, rotary pumps, refrigeration, steam engines, telephones, telegraphs, &c.; gyro stabilisers, compasses, &c. We feel sure that this second volume, used in conjunction with the first, will be of much value to motor-ship engineers.

Wireless Telegraphy Notes for Students. By W. E. Cook. London: Sir Isaac Pitman and Sons, Ltd. 1935. Price 7s. 6d.—Believing that the practice of dictating notes in wireless schools is of doubtful value and that of leaving students to make their own notes is dangerous unless they are checked at frequent intervals, Mr. Cook has been tempted to write this book, which may be studied in conjunction with suitable text-books. The volume relates to the theoretical part of the wireless course given at Air Service Training, Ltd., Hamble, Southampton, and the field covered meets the requirements of those qualifying for the Postmaster-General's air licence for wireless telegraphy operators. The notes are based on the author's teaching experience, which has led him to conclude that certain branches of the subject call for much longer and more detailed notes than others.

Meter Engineering. By J. L. Ferns. London: Sir Isaac Pitman. Price 10s. 6d.—Apart from the fact that the subject matter of this book has been brought up to date and portions have been rearranged in a more convenient manner, this second edition does not differ from the first edition, published in 1932. Like its predecessor, the present volume explains the fundamentals of electricity meters and the methods of testing and maintaining them. The mathematical knowledge essential to derive full benefit from the book includes elementary integration and vector summation. Engineers to whom the book will mainly appeal are those associated with the metering departments of supply undertakings.

BOOKS RECEIVED.

Diesel and Other Internal Combustion Engines. By H. E. Degler. London: Crosby Lockwood and Son, Ltd., Stationers' Hall-court, E.C.4. Price 10s. 6d. net.

Modern Plan Copying. By B. J. Hall, M.I. Mech. E., and B. Fairfax Hall, M.A. London: Sir Isaac Pitman and Sons, Ltd., Parker-street, W.C.2. Price 5s. net.

Theory of Machines. Third edition. By L. Toft, M.Sc., and A. T. J. Kersey. London: Sir Isaac Pitman and Sons, Ltd., Parker-street, W.C.2. Price 12s. 6d. net.

Motor Racing and Record Breaking. By G. E. T. Eyston and B. Lyndon. London: B. T. Batsford, Ltd., 15, North Audley-street, W.1. Price 7s. 6d. net.

Psychology in Business and Industry: An Introduction to Psychotechnology. By J. G. Jenkins. London: Chapman and Hall, Ld., 11, Henrietta-street, W.C.2. Price 12s. 6d. net.

The Theory of Emulsions and their Technical Treatment. Third edition. By W. Clayton, D.Sc. London: J. and A. Churchill, Ld., 40, Gloucester-place, W.1. Price 25s. net.

Design of Concrete Structures. Third edition. By L. C. Urquhart and C. E. O'Rourke. London: McGraw Hill Publishing Company, Ltd., Aldwych House, W.C.2. Price 25s. net.

Mercury Arc Current Converters. By H. Rissik, B.Sc., and Captain J. M. Donaldson, M. Inst. C.E. London: Sir Isaac Pitman and Sons, Ltd., Parker-street, W.C.2. Price 21s. net.

The Surface Condenser: A Survey of Modern Condenser Practice. By B. W. Pendred, A.M.I. Mech. E. London: Sir Isaac Pitman and Sons, Ltd., Parker-street, W.C.2. Price 8s. 6d. net.

The Public Works, Roads, and Transport Exhibition.

No. III.

(*Continued from page 539, November 22nd.*)

Pegson.

THE firm of Pegson, of Coalville, Leicestershire, was exhibiting the "Counter Current" mixer, illustrated in Figs. 39 and 40. It consists of an all-steel circular pan revolving on four trunnions and incorporating a mixing star rotating in the opposite direction to the pan. By means of this mechanism the batch is rapidly circulated immediately it enters the mixer pan and is intimately and consistently mixed in a very short time. This mixing principle

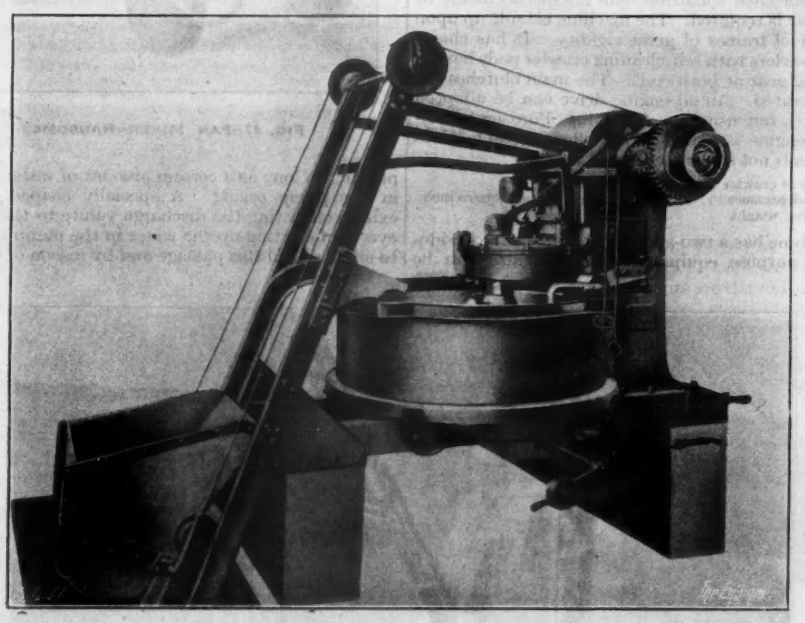


FIG. 39—"COUNTER CURRENT" CONCRETE MIXER—PEGSON

is not only claimed to secure a complete homogeneity of all the constituent parts of the mix, but to give a very high strength yield with a small cement content. Conveniently centralised controls and a quick-action discharge door enable the numerous batches to be quickly mixed.

A freely hung kneading roller eliminates disintegrating, balling, and crushing of the aggregate. Analytical records, it is said, have proved that complete uniformity of texture and quality of mix over

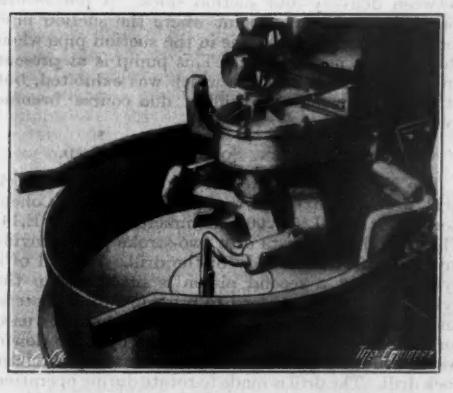


FIG. 40—PAN AND MIXING STAR—PEGSON

long periods can be guaranteed. The Pegson counter current mixer can be supplied in several sizes, portable or fixed units, open or closed mixing pan and with or without a loading skip.

The Patent Lightning Crusher Company, Ltd.

Crushers, granulators, and a refuse masticator were exhibited by the Patent Lightning Crusher Company, Ltd., of 14A, Rosebery-avenue, London, E.C.1. The crusher is of the rotary swing hammer type. It is claimed by the firm that swing hammers deliver a far more effective shattering blow than fixed hammers, that comparatively low peripheral speeds can therefore be adopted, and that the delivery of oversize rejects is reduced. The crusher has great flexibility and is competent to crush down to very fine dimensions as well as to crush to coarser grades suitable for concrete aggregates and road chippings. As well as for crushing stone, it can be used for reducing metals and organic substances.

In Fig. 41 we have chosen for illustration another product of the firm, termed a refuse masticator. It is a high-speed centrifugal disintegrator, pulveriser, and mixer combined, specially designed for dealing with house refuse as collected from the domestic dustbin. Only such materials as metal, large tins, leather, &c., and long rags are thrown aside by the workmen in the act of feeding the machine. It disintegrates the refuse, whether wet or dry and whatever its composition, to a uniform dark mould. The masticator consists of a casting in box form with an open base, divided in half and hinged at its horizontal centre, through which a steel shaft is fitted, having mounted upon it two special cast steel discs of heavy construction. Between the discs two U-shaped manganese steel hammers are swung upon powerful pins which pass through the discs. At each end of the shaft, driving pulleys are mounted to ensure smooth running and even loads on the bearings. The latter are provided with phosphor-bronze bushings of ample proportions. When the shaft is set in motion the hammers take up a radial position in relation to it.

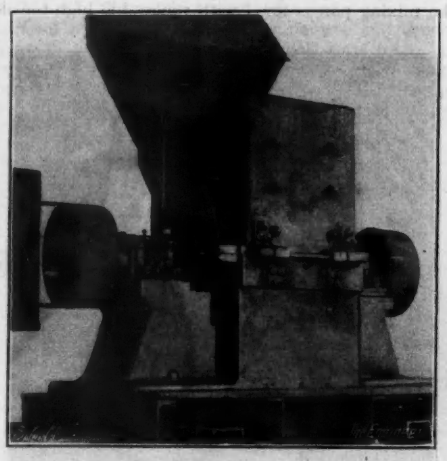


FIG. 41—REFUSE MASTICATOR—LIGHTNING CRUSHER

In the lower half of the box and closely following the path of the face of the hammers is fitted a set of transverse screen bars with projections on their sides to form spaces between them. The normal speed of revolution of the driving shaft is 950 r.p.m. The refuse fed in through the feed hopper is struck with great force by the rotating swinging hammers and shattered. Further breaking up of the material takes place between the hammers and the lining plates. The friction of the elements composing the refuse while in suspension assists disintegration. The final disintegration is effected by trituration between the hammers and the grinding plate. When reduced to the proper degree of fineness the material drops through the spaces between the screen bars and passes out of the bottom of the machine. The hammers on meeting any unsually hard material swing back a little and then go forward immediately to strike again. This action minimises possible danger from metal in the refuse. The screen bars can be removed easily and replaced by others having wider or narrower spaces between them to regulate the fineness to which the refuse is to be reduced and to meet seasonal variations in its composition.

The Horstmann Gear Company, Ltd.

Automatic lighting appliances for the control of gas and electric lamps for public lighting were exhibited by the Horstmann Gear Company, Ltd., of Heybridge Works, Bath. Apart from the fact that the firm's clock-control apparatus for automatically lighting and extinguishing lamps is claimed to save from 12s. to 20s. per lamp per annum, it can be arranged to control lighting in accordance with various requirements. Certain lights can, for example, be extinguished at midnight, whilst other lamps in key positions are left burning all night or lamps extinguished at midnight can be brought into service again in the early morning. Arrangements can also be made for switching over automatically from high-power to low-power lights at midnight. Controllers were shown for different types of lamps and for different industrial purposes. A newly developed clock controller is the "Comet" controller, an automatic ignition device which, save for about two seconds per day, dispenses with the usual by-pass, with the result that the by-pass consumption per lamp per day is only 0·0005 cubic foot. Other exhibits consist of the Newbridge gas switch for the distant control of lights, the Newbridge gas fire switch, and electrical time switches. The exhibits cover all forms of automatic time switching for street, shop window, and sign lighting.

Turner's Asbestos Cement Company.

Asbestos cement pipes, which this year include a 1½in. diameter size, were exhibited by Turner'sAsbestos Cement Company. An interesting joint was shown, called the "Everite," which is all asbestos cement, and is of the flexible screw type. In Fig. 42

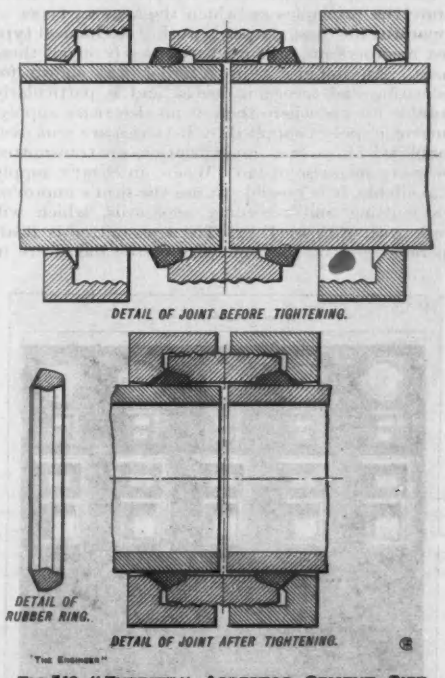


FIG. 42—"EVERITE" ASBESTOS CEMENT PIPE JOINT—TURNER'S ASBESTOS

diagrams of the method of working are shown. The joint consists of one central collar machined accurately out of asbestos cement of the same tensile strength as the "Everite" asbestos cement pressure pipes with which they are used, two flanges of the same material and two rubber rings backed with a hard rubber to enable the flanges to be screwed without binding on the rubber. The joints can be rapidly assembled and are tightened up by means of pipe grips. They are manufactured at present in sizes from 2in. to 8in. and for pressures up to 400ft. head. Similar joints, but with the rubber rings tipped with asbestos to prevent the contents of the main coming into contact with rubber, are supplied for use with gas mains.

The Lea Recorder Company, Ltd.

Electrical transmitting and recording apparatus was shown working in conjunction with a trapezoidal "standing wave" flume on the stand of the Lea Recorder Company, Ltd., of Recorder House, Cornbrook Park-road, Manchester. To obtain records of small flows, the company has long used with success the V notch as a basis of measurement,

whilst for larger flows the rectangular weir or a combination of the V notch and weir has been employed. The "standing wave" flume has been introduced for accurate measurement where loss of head has to be reduced to a minimum or where there is a tendency for excessive silting to occur. Measurements made by any of these methods are interpreted and recorded by recorders, which may be situated at a point remote from the place of measurement. It is often a decided advantage to be able to record variations of water level in reservoirs on an instrument at some centralised spot or to record in the same way the flow of streams which feed a reservoir. With modern sewage treatment there is also a greater need than in the past for

FIG. 43—RATE OF FLOW INDICATOR—LEA RECORDER

co-ordination of the various processes to ensure the production of a perfect final effluent.

The exhibit mentioned and others served to demonstrate the principles on which the various types of apparatus for these purposes work. Mechanical type Lea recorders are still used extensively in all these cases. An impulse type recorder was shown for indicating and recording levels, and is particularly suitable for use where there is no electricity supply. Current impulses supplied by batteries are sent over double telephone lines, and variations are transmitted for every inch rise or fall. Where an electric supply is available, it is possible to use the firm's improved transmitting and recording apparatus, which will work with A.C. or D.C. The transmitter is float-operated and no moving parts of the meter are in

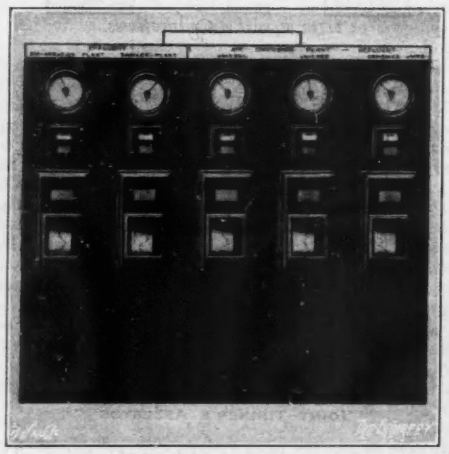


FIG. 44—INDICATOR AND RECORDER PANEL—LEA RECORDER

contact with the water and no mercury is used. Nor is there any possibility of trouble arising as the result of oxidisation of contacts. The electric supply may be at the transmitting or receiving end of the system or at some intermediate point, and provision is made to ensure that the records are independent of voltage variations. The system may be used for recording levels, and is particularly suitable for recording flows over weirs or in flumes. When used for measuring flows in streams, &c., the well-established spiral drum method of integration is incorporated. The transmitter may be used in conjunction with notches, weirs, or flumes, records being obtained in many cases down to within 1 per cent. of the maximum flow. A transmitter with a special "rectifying" device, giving an evenly divided scale, is shown in Fig. 43.

It is sometimes desirable to have all recorders centrally situated, so as to control in a more effective manner the various processes of sewage treatment or to arrange the times of pumping in connection with water supplies. For such purposes various types of instruments are available such as indicators, recorders, and, in the case of flow measurements, integrators. The indicators have long evenly divided scales, whilst the standard recorder is supplied with a roll chart having a travel of ½in. per hour. Integrators have clear reading cyclometer dials, and are mounted together with the other instruments on polished black Sindanyo panels, as shown in Fig. 44.

RANSOMES AND RAPIER, LTD.

Naturally one expected to find on the stand taken by Ransomes and Rapier, Ltd., an excavator. The visitor was not disappointed, for a ¾ cubic yard machine was exhibited and is illustrated in Fig. 45, equipped as a shovel. This excavator has a four-purpose equipment, so that it will act as a trencher, shovel, skimmer-scoop, and 2-ton crane. Changing from one combination to another is a simple re-arrangement of the bucket, handle, and pulleys, and takes, it is said, less than an hour even when carried out in the field. The boom is unaltered, except in position for each condition, and no special tackle or lifting gear is required. The machine is built up upon welded steel frames of great rigidity. It has chain-driven crawlers with self-cleaning crawler pads having tensioning gear at both ends. The main clutches are servo-operated. An oil engine drive can be adopted if required, but usually a 32/25 h.p. Fordson petrol-paraffin engine is fitted. The following table gives some details not so far mentioned :—

Width of crawler tracks	11½in.
Ground pressure	7¾ lb. per square inch
Working weight	7½ tons

The machine has a two-speed travelling gear. Besides the four-purpose equipment the excavator can be

FIG. 45—THREE-EIGHTH YARD FOUR-PURPOSE EXCAVATOR—RANSOMES

fitted with additional equipment to act as a drag-line or grab.

Another illustration—Fig. 47—shows the 4ft. 6in. pan mixer shown by the firm. This device is designed to crush certain aggregates whilst mixing and is driven by a 5 h.p. petrol engine. It will be observed that the pan is driven through overhead gearing, so that the gears are kept away from the mixed material. The mixing pan is lined with renewable high-tensile

FIG. 46—PORTABLE PUMPING PLANT—RANSOMES

steel segments, which are lighter than the frequently used cast iron liners. Chilled iron rollers with gun-metal bushes revolve on a spring-loaded adjustable axle. The discharge gate is operated through rack and pinion by a large hand wheel. Complete, the mixer weighs 35 cwt. Two tilting drum concrete mixers and a 10/7 cubic feet rotary drum mixer were also shown.

The little pumping plant illustrated in Fig. 46 has a rated capacity of 10,000 gallons per hour and is driven by a 3 h.p. "Coborn" air-cooled petrol engine. The pump is of the centrifugal type with a two-bladed open impeller able to pass big solids and by an ingenious internal arrangement is caused to be self-

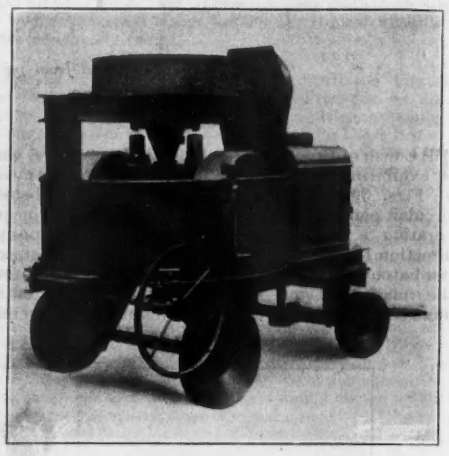


FIG. 47—PAN MIXER—RANSOMES

priming so long as a certain amount of water remains in the pump casing. A specially shaped passage exists connecting the discharge volute to the suction eye. On starting up the water in the pump is caused to circulate *vid* this passage and by reason of the high velocity of the jet passing into the eye a vacuum is created in the suction pipe. When the pump starts to run full a swinging blade on the volute side is lifted by the rush of water and closes the passage between delivery and suction sides. A non-return valve situated at the point where the suction pipe joins the casing holds prime in the suction pipe when the pump is not running. This pump is at present only made in the 2in. size which was exhibited, but other sizes, we learn, will in due course become available.

GEORGE COHEN, SONS AND CO., LTD.

The Warsop road breaker and the Warsop rock drill were displayed on the stand of George Cohen, Sons and Co., Ltd., 600, Commercial Road, E.14. The rock drill consists of a two-stroke petrol engine inverted within the body of the drill. Instead of a cylinder head a second piston is fitted within the cylinder, which is stepped to provide two diameters, and which carries at its lower end the hammer used for drilling. The machine from the cylinder downwards follows the design of the ordinary pneumatic rock drill. The drill is made to rotate during operation by the design of the guides, and the exhaust gas from the operating cylinder is carried down the drill steel to clear the hole. The upper end follows the normal design of crank case compression, two-stroke, petrol engine, a fly-wheel magneto being fitted. An explosion having occurred between the two pistons the upper or engine one compresses a further charge in the crank case, while the lower or hammer piston operates the drill. As the upper piston moves it uncovers a port which allows some of the combustion gases to pass down to below the larger diameter of the working piston, thus returning it to its upper position. The engine piston returns by the effect of the crankshaft and fly-wheel, and the next firing stroke occurs. To start the drill the crankshaft is rotated as with any petrol engine, the first firing stroke providing power to lift the working piston and bring it into action on the second stroke. In Fig 48 we illustrate the Warsop road breaker which functions on the same principle. In addition to these, George Cohen, Sons and Co., Ltd., were exhibiting a Pegson rammer

as shown by Pegson, Ltd., a Premier portable emulsion sprayer, and a new all-metal, hand-operated bundling press for baling waste paper, rags, leather, tin clippings, straw and hay, &c., the net weight of which is approximately 2½ cwt. only. The material to be pressed is shot in, a loose top is put on, the rack is wound down quickly with a small handle, pressure being applied by a ratchet. Slots in the back of the press, &c., allow the bale to be bound whilst under pressure. The dimensions of the bale are approximately 80in. by 15in. by 20in. to 30in., and the weight about 200 lb., according to the class of material put into the box.

There was also exhibited the P 10 B.E.N. portable compressor, which has been primarily introduced and designed for two-gun operation to meet the needs of railway companies, painting contractors, &c. For driving the compressor a 2 h.p. electric motor, or 2⅓ h.p. "Coborn" air-cooled petrol engine, manufactured by Kryn and Lahy (1928), Ltd., at Letchworth, is used. The compressor and engine are mounted on a rigid, folded steel frame carried by two 10in. solid rubber-tired wheels and one 8in. rubber-tired castor wheel. The machine can be readily manœuvred. A backward movement of the handle sprags the machine firmly in position, with the front castor and rear wheel just clear of the ground. Thus the machine is steady in use owing

FIG. 48—WARSOP ROAD BREAKER—COHEN

to the absence of vibration. The control of the pressure is secured by an automatic air unloader or governor, which is adjustable from 20 lb. to 80 lb. per square inch. In common with all B.E.N. units, special attention has been given to the cooling system. A coiled copper after-cooler is interposed in the air blast of the vaned compressor fly-wheel. Air is thus effectively cooled before it is passed along the copper outlet pipe from the receivers to the condensate manifold. Another B.E.N. portable compressor set was also exhibited. This set is mounted on large diameter wheels (20in.) with pneumatic tires, and can be moved from point to point over rough ground with ease. It is thus invaluable to gas, water, and electricity companies, and contractors for testing sections of mains, and for testing and desiccating electric cables. When fitted with a caulking hammer it is a very handy and economical unit for making joints. A two-point sprag is provided and two fixed legs take the weight from the pneumatic tired wheels when the machine is in use. Power for this plant also is provided by a "Coborn" engine.

THOMAS SMITH AND SONS (RODLEY), LTD.

The new Two-Ten single bucket excavator made by Thomas Smith and Sons (Rodley), Ltd., has a capacity of ⅜ cubic yard. Its weight is 7½ tons, and it is operated by oil engine, petrol/paraffin engine, or electric motor, according to the requirements of the purchaser. The oil engine provided is a 23/27½ h.p., two-cylinder model, of 115 mm. bore by 130 mm. stroke. Bosch fuel injection is fitted, and the engine output is controlled by a variable-speed centrifugal governor.

The petrol/paraffin engine is a 105 mm. bore by 127 mm. stroke, four-cylinder unit, also governor controlled, while the electric motor fitted has single-switch control, so that in all three cases the power output is controlled by the driver with considerable simplicity. The excavator is an excellent example of sound modern design and good workmanship, all gear wheels in the superstructure, for example, being machine cut from the solid. The carriage drive is through manganese steel bevels. The machine is quickly convertible to a navvy shovel, skimmer, or trencher, with the excavator jib, while with a longer jib the machine can work as a drag-line, crane, grab crane, or pile driver. For each duty a specially designed bucket is available. In Fig. 49 is shown a view of the caterpillar carriage on which the machine is mounted.

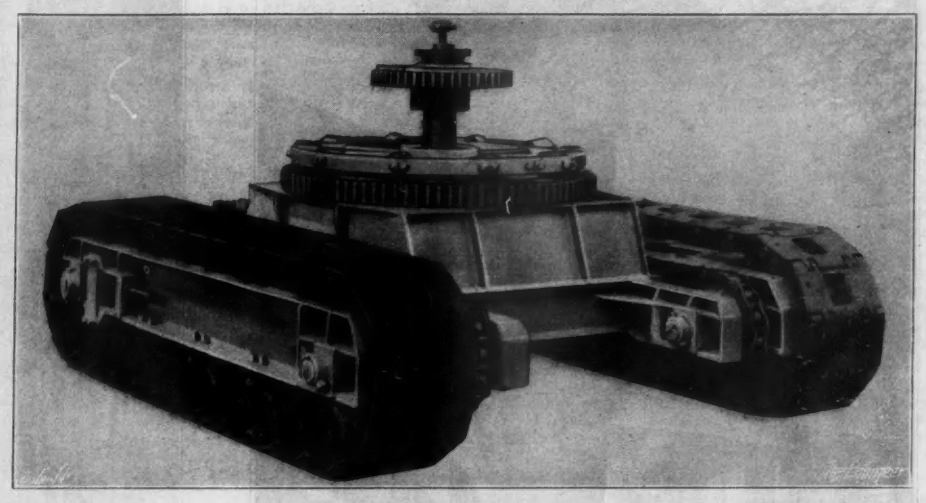


FIG. 49—CATERPILLAR EXCAVATOR CARRIAGE—THOMAS SMITH

The track pads are 13½in. wide, linked by nickel steel pins, and result in a ground pressure of only 7 lb. per square inch. Notable points are the width between the tracks and the 10in. ground clearance provided. A clear view is given of the live ring mounting provided for the superstructure with its ten tapered rollers. Accessible adjustment for stretch in the tracks is provided, as shown, on the rear drive wheels,

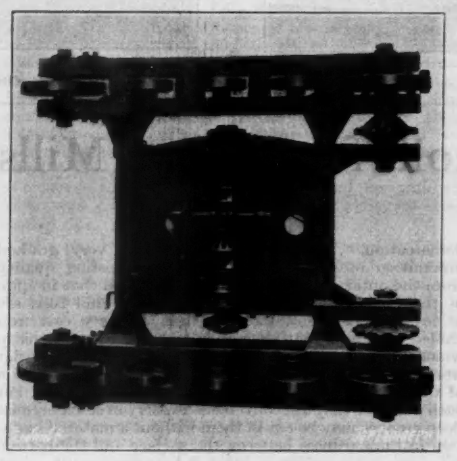


FIG. 50—CARRIAGE FRAME—THOMAS SMITH

which are spring mounted to absorb driving shocks from the track. The method of driving will be seen in Fig. 50. Power is transmitted down the central vertical shaft to the bevel gear shown, and thence through dog clutches to each track sprocket. The final drive is by chains. The method of suspending the machine on the tracks is shown in this view, as well as the grouped grease nipple lubrication system

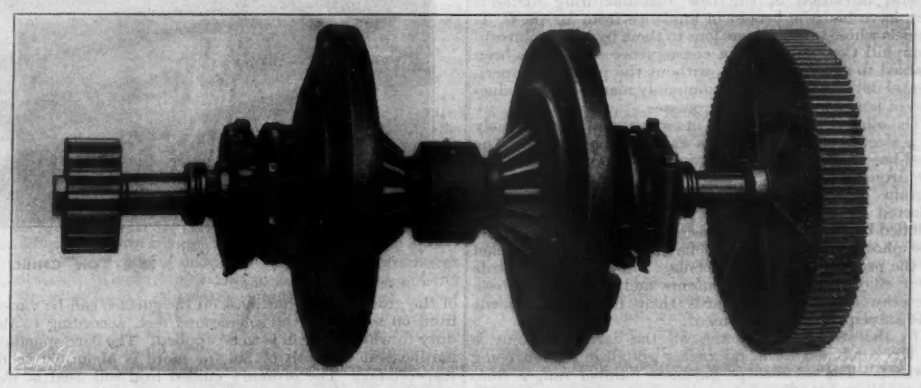


FIG. 51—REVERSING SHAFT—THOMAS SMITH

provided. The dog clutches are operated by the driver to steer the machine. A useful fitment is a spragging device which locks the machine from travelling in one direction or the other as required, without obstructing its movement in the opposite sense. The all-welded steel carriage frame can be seen in Figs. 49 and 50. On it is carried the superstructure, which is shown in Fig. 52. The control position for the engine and the rope barrels with their servo-operated clutches is seen in Fig. 52. The clutch gear used for the barrels is most ingenious. A small clutch brings into action a large band clutch causing the barrel to rotate with the shaft. The clutches are, in consequence, very light to operate. Band brakes are fitted in two interchangeable halves, so as to obtain maximum wear from the linings. The barrel shaft is driven from the reversing shaft, shown in Fig. 51, which incorporates a clutch-operated reversing gear.

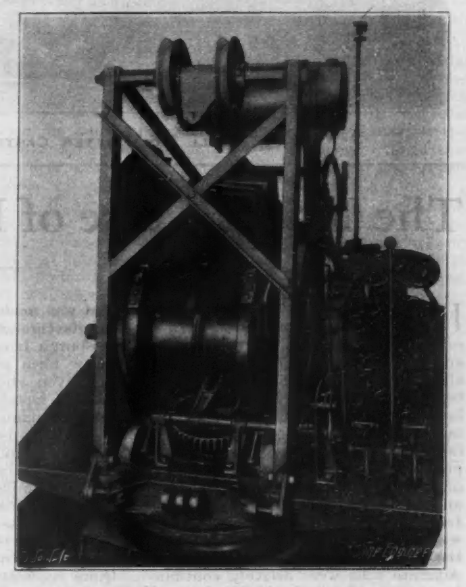
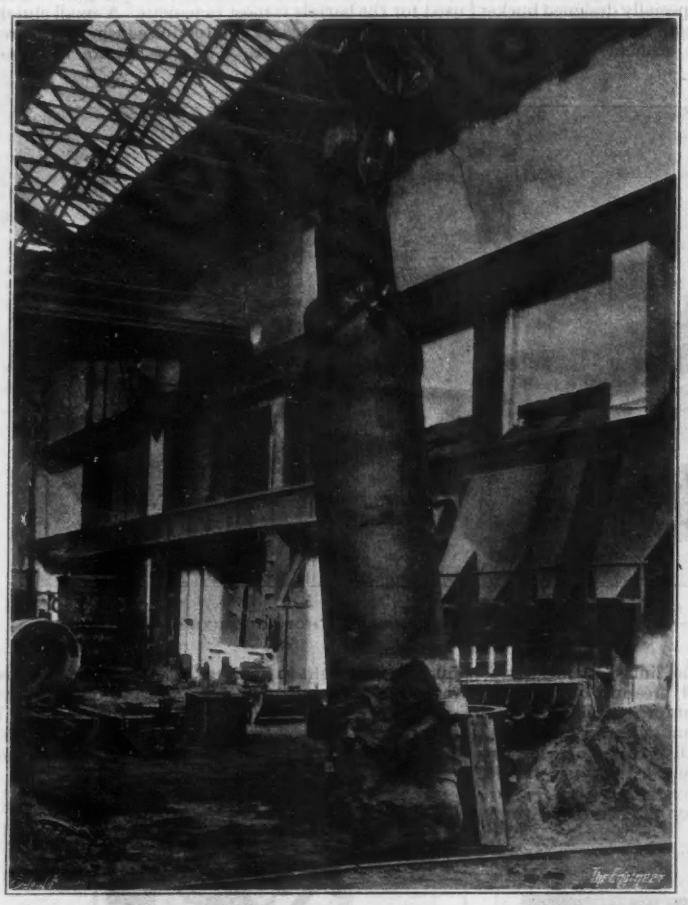


FIG. 52—SUPERSTRUCTURE—THOMAS SMITH

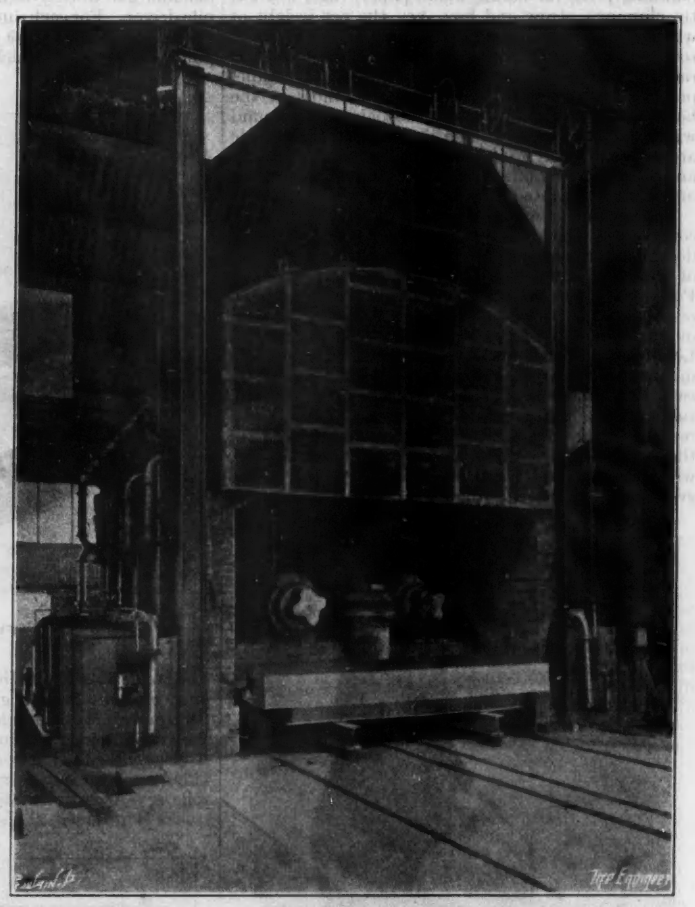
The clutches connect up the slewing and travelling drives to either of two pinions to obtain reversed motion. They are over-sized flat plate fibre-lined clutches, and are easily dismantled for relining, without disturbing the shaft. As a trencher the machine has an outreach of 21ft. and can dig trenches 12ft. 6in. deep. Its speed slewing is 6 r.p.m. It digs 90ft. per minute. Its travelling speed is from ⅝ to 1¼ miles per hour.

(To be continued.)

THE PRODUCTION OF ROLLING MILL ROLLS



CHILL ROLL AFTER CASTING



OIL-FIRED ANNEALING FURNACE

The Manufacture of Rolls for Rolling Mills

IN the year 1913 an important development was made in America in connection with the manufacture of rolls for rolling mills. In that year the Pittsburgh Iron and Steel Foundry Company produced a new form of alloy to which the name "Adamite" was given and began to manufacture from it rolls for use in metallurgical works. During the introductory stages manufacturing irregularities were experienced and some faulty applications were made but very speedily sound production processes were evolved and in a short time the new rolls became widely adopted in most classes of mills and wrought a considerable change in rolling mill practice. In 1922 the Pittsburgh Foundry Company's business was absorbed by the Macintosh-Hemphill Company of the same city and the development and application of Adamite rolls were actively continued. Quite recently, by arrangement with the Macintosh-Hemphill Company, the manufacture of Adamite rolls in this country has been begun by R. B. Tennent Ltd. of Whifflet Foundry, Coatbridge, Scotland, a firm which since its foundation in 1857 has specialised mainly in the production of all forms of heavy iron and steel rolls. To provide the requisite facilities for the production of these rolls has necessitated an extensive reorganisation of Messrs. Tennent's works and their equipment with much new plant and machinery. In this connection and for the general initiation of the new manufacturing methods they have had the benefit of guidance from Mr. F. C. T. Daniels whose services were lent to them by the Macintosh-Hemphill Company. As a consequence they have been enabled to start production without the period of experimental development which commonly marks the introduction of new manufacturing processes.

The alloy Adamite is made in two general forms namely as a steel-base alloy and as a cast iron-base alloy. The steel-base variety is produced in five different grades and the iron-base variety either as chilled castings or as "grain" castings. The particular variety and grade is selected in accordance with the particular duty to be fulfilled by the rolls. In all cases the alloys have the same low phosphorus content and have chromium and nickel as the principal alloying elements. They differ as regards their silicon and carbon contents and, in the steel-base varieties at least, as regards their furnace treatment and subsequent heat treatment.

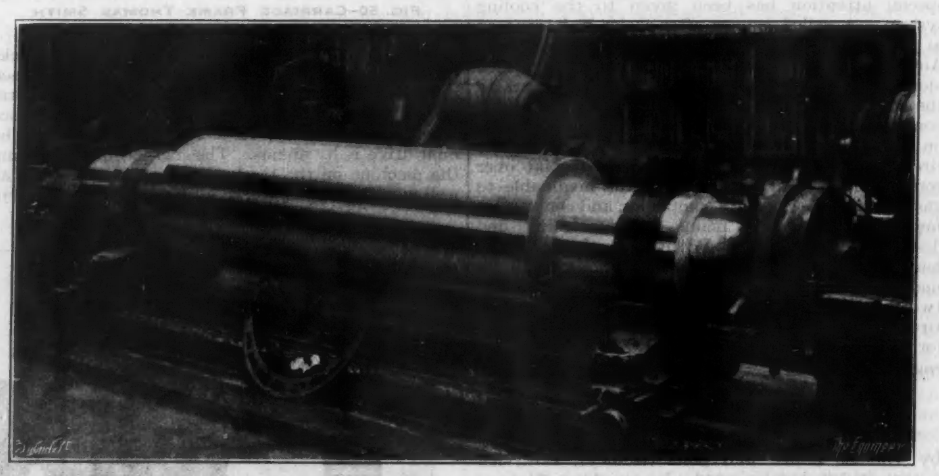
In the steel-base varieties all the carbon content is in the combined form, no visible graphitic carbon being present. The scleroscope hardness number ranges from 32 to 55 and throughout the mass of any one grade the hardness is substantially constant. Cogging mill rolls are usually made of Adamite of 32 scleroscope hardness number. For structural roughing mills a hardness of 35 is considered best and for intermediate mills one of 42 is commonly adopted. Finishing rolls may have a hardness of 48 while rolls for special service, such as sizing rolls for tube mills, may be as hard as 55.

The Adamite iron-base chill roll differs from the ordinary chilled cast iron roll in an important structural respect. The hard outer surface shades off very gradually into the grey iron central portion without a noticeable line of demarcation. There is a corresponding very gradual diminution of the hardness and wear-resisting quality from the outer surface inwards. It is stated that in spite of their hard internal structure Adamite chill rolls are at least 30 per cent. stronger than ordinary cast iron chilled rolls and that they may be used in positions in which ordinary rolls would fail. They are used for flat work in bar, skelp and strip mills and for the production of the smaller shapes in merchant and guide mills. For such purposes they are convenient to carry in stock because deep grooves may be cut in them without a material variation in the hardness between the surface and the bottom of the groove. The hardness on the surface can be varied from 60 to 70, by the scleroscope test, according to the duty to which the roll is to be applied. The corresponding hardness at a depth of 3in. or more is about 50 to 60 respectively. The ordinary chilled iron roll used in this country for the purposes named above has a surface hardness of 55 to 60. Hence instead of casting a chilled roll closely to the finished form it should be possible to take a plain Adamite roll from stock and turn it to the finished form without any sacrifice of hardness at the bottom of the turned groove.

The iron-base "grain" rolls are similar in their properties to the chill rolls. They are used mostly in the larger sizes and principally in billet mills and in the finishing stands of structural mills. They are cast closely to shape as regards their collars and grooves and are hardened by the use of chill rings in the moulds.

The steel-base compositions are produced in a 50-ton open-hearth furnace and the iron-base alloys in reverberatory furnaces one of which is of 40 tons capacity and is claimed to be the largest of its type in Great Britain. The melting plant also includes two cupolas. In addition to the control of the composition and the melting conditions, the temperature at which the metal is poured into the moulds is of very great importance. It is controlled, as might be expected, by pyrometers. The rolls are cast on end. The metal enters near the bottom of the mould with a centrifugal action which promotes soundness on the surface of the roll.

The heat treatment to which the castings are subjected plays a highly important part in their successful production. It necessitates not only a careful control over the heating of the rolls and the maintenance of the temperature for the prescribed time but also over the subsequent cooling which must be performed slowly. The heat treatment plant includes an oil-fired annealing oven of 100 tons capacity supplied by James Howden and Co. Ltd. of Glasgow, the temperature of which is controlled thermostatically and recorded electrically. Additional furnaces of 75 and 50 tons capacity are now being erected.



35½-TON CHILL ROLL IN THE LATHE

In the machine shop the new equipment installed for the production of Adamite rolls includes a 36in. and a 30in. roll turning lathe made to Messrs. Tennent's requirements by Craven Brothers (Manchester) Ltd. and a large roll grinding machine made by the Churchill Machine Tool Company Ltd.

Herewith we reproduce three photographs, one showing a chill roll, having a finished weight of 35¼ tons, just after being cast, another showing the same roll in the lathe and a third showing the 100-ton oil-fired annealing furnace.

Rail and Road.

THE appeal of the Railway Assessment Authority and certain public bodies against the Railway and Canal Commission in the case of the Southern Railway rating is now being heard in the House of Lords.

THE Great Western Company's sleeper yard at Hayes is a very old institution and, as announced in our Railway Engineering article on January 18th last, it was being remodelled. The work is now completed and the depôt can deal with the creosoting, chairing, &c., of 500,000 sleepers a year, all of which work can be done under cover.

MOST railwaymen speak of the loops on single lines at which trains pass each other as "crossing places"—that was done in the official notices as to the work to be done by the companies to relieve unemployment. The correct term for these facilities is "passing places," as the two trains do not always cross each other; a less important train may be overhauled and passed by a more important one going in the same direction. These do not cross, but pass each other.

THE Ministry of Transport railway statistics for August show that, compared with the corresponding month of 1934, the number of passenger journeys increased by 6·8 per cent. and the receipts from passengers by 5·0 per cent. The tonnage of freight fell by 1·2 per cent. and the freight train receipts by 1·8 per cent. The freight train mileage had a decrease of 0·2 per cent.; the average train load was the same at 123¾ tons and the net ton-miles per engine hour increased from 462¾ to 467¼.

THE National Union of Railwaymen has been desirous of bringing into one organisation all the transport workers in railway, road, and air services. The scheme has been submitted to the Transport and General Workers' Union and to the National Union of General and Municipal Workers, but the report presented to a special conference of the N.U.R. on November 28th stated that although there was a greater desire than formerly for a consolidated organisation, there were such difficulties in the way that the project could not at present be carried further.

THE November issue of the *Great Western Railway Magazine* refers to the use at Bodmin-road Station of a mirror that enables the signalman, whose box is awkwardly situated, to see that up trains have the tail lamp that signifies that the train has passed complete. This is not an original idea, as, over forty years ago, the signal-box at a station on the Lancashire and Yorkshire Bury-Accrington branch was provided with a mirror to advise the man of the approach, down a steep hill, of vehicles that had to cross the line so that he could have the gates opened and prevent a possible collision with the gates.

ADDRESSING the Manchester University Economics and Commerce Society on November 19th, Mr. R. Stuart Pilcher, the general manager of the Manchester Corporation Transport Department, mentioned, under the heading of "Economics of Transport," the question of tram *versus* bus. By the supersession of trams by buses, routes which had been run at a loss had been made profitable. On one section where buses had been introduced the department had carried 2,500,000 more passengers in a year. One of the advantages of trollybuses over trams was that the former could be drawn up to the pavement like the buses. That fact would induce women especially, who were the transport department's greatest customers, to travel in them more often.

AN Order made by the Minister of Transport de-restricting a length of the East Lancashire road in the borough of Swinton and Pendlebury is of particular interest. The section was recommended for de-restriction by the R.A.C. and A.A. some months ago. The two organisations referred the matter to the authorities concerned and a Ministry of Transport inquiry was held. It is understood that the inspector considered that the motoring organisations had proved their case, and he reported in favour of de-restriction. Despite this report the local authority declined to take action, and accordingly the Minister has now made an overriding Order under the Road Traffic Act, 1934, derestricting the road. This is the first instance in which the Minister has found it necessary to make an Order overriding a local authority.

THE L.M.S. Railway has completed an important coal purchase in Staffordshire, but the coal will never be mined. A section of one of the coal seams under the main line from Euston to the North at Polesworth, Staffs., between Nuneaton and Tamworth, has been acquired by the company in order to avoid undermining of the line. At present, owing to previous mining activities, all trains passing over the area have to reduce speed to about 30 m.p.h., involving about two minutes' delay to each train. The company anticipates that with the acquisition of certain mineral rights in the vicinity, and after engineering attention, the speed restriction at this point will be completely removed. Removal of the speed restriction at Polesworth will enable express trains to traverse the area at their normal speed of 65–75 m.p.h., and will have an important bearing both on punctuality and on the question of future acceleration.

CASES of flooding of the permanent way and of landslips—like that between Winchfield and Hook on November 17th—have to be reported to the Ministry of Transport, but on only three occasions during the present century has it been considered necessary to inquire into a railway accident that resulted from such a mishap. The first of these three cases was the most serious, as it resulted in seven passengers losing their lives. It occurred on January 19th, 1918, at Little Salkeld, on the Settle and Carlisle section of the Midland Railway, when that company's down day Scottish express ran into the obstruction. On January 3rd, 1925, a settlement in the roadway at the bottom of an embankment at Tirphil, on the old Rhymney section of the Great Western, led to a cavity in the railway, into which a freight train fell and the two enginemen were killed. A slip of the embankment carrying the railway in Vriog Cutting, Fairbourne, on the Cambrian Railway section of the Great Western, on March 4th, 1933, led to the engine of a mail train being derailed and rolling down on to the seashore. The two enginemen lost their lives there also.

Miscellanea.

AT a special meeting of the Gloucestershire County Council a resolution was passed authorising the promotion of a Bill in Parliament for the construction of a road bridge across the river Severn.

A NEW coke oven plant is to be constructed for John Bowes and Partners, Ltd., at Monkton, near Jarrow. The new ovens, which will cost about £250,000, will consume some 200,000 tons of coal a year.

INVESTIGATION has shown that the natural gas fields at Gogha, in Western India, have great commercial possibilities, if developed on scientific lines. A company is being formed to exploit these natural resources, it is reported.

IT is reported that the Standard Oil Company of California is to construct an oil refinery in the Bahrein Islands in the Persian Gulf. The refinery will have an initial capacity of 10,000 barrels daily and will probably commence operations in the middle of next year.

IN order to commemorate the late Sir James Walker, Professor of Chemistry at the University of Edinburgh from 1908 to 1928, it is proposed to establish a fund for a Walker Memorial Lecture to be delivered annually by an eminent chemist invited to Edinburgh by the Edinburgh University Chemical Society for that purpose.

A NEW refrigerant in the form of frozen sodium chloride brine has been introduced in the United States for use in cold storage. The new material is marketed in small, loose, broken pieces, and in blocks of about 30 lb. each. It is made of brine comprised of about 23 per cent. salt and 77 per cent. water by weight, and is said to melt at a lower temperature and more evenly than mixtures of salt and crushed ice.

THE beneficial effects of trade agreements upon the industries of Great Britain was referred to by Sir John Caulcutt, the new President of the Institute of Bankers, in the course of his inaugural address. The influence of the policy pursued on the recent expansion in our export trade, he said, was shown by the fact that in the first six months of 1935 exports to the foreign countries with which agreements were then in force were greater by £7,627,000, or 17 per cent., than in the first half of 1933, when these arrangements were not in operation. On the other hand, the increase in exports to all other foreign countries was £5,034,000, or only 9½ per cent.

PLANS are being drawn for a large dam on the San Juan River for the Mexican Government's irrigation project, which will reclaim about 150,000 acres of land in the Lower Rio Grande Valley, situated opposite the irrigated and developed area on the American side of the river, says *Engineering News-Record*. The construction of the dam and canal system will involve an expenditure of about 8,600,000 dollars. The site of the proposed dam is a short distance above where the San Juan River empties into the Rio Grande. The structure will not only be used to conserve the flood waters of that stream, but will help to prevent overflows of the Rio Grande along its lower course.

IN a paper before the Public Works Congress, Lieut.-Colonel G. E. Morgan dealt with the purification of water by ozone treatment. He stated that in the production of 1 gramme of pure ozone, approximately 20 kW of electrical energy is absorbed. Thus, at 0·5d. per kWh, 1 gramme of pure ozone would cost about 0·01d. About 5 grammes of ozone is required to purify 1000 gallons of filtered water, so that 5s. will pay for the electricity needed to purify 1,000,000 gallons. Owing to the simplicity of operating ozone water treatment plant, the supervision and labour costs are low, semi-skilled attendance only being necessary. Maintenance and repair costs are also small, since most of the plant is static, apart from the motor-driven air blower and high-voltage motor alternator sets.

AN abstract in the *Chemical Trades Journal* deals with a number of investigations on the composition of lead anodes, for use in the electrolytic production of zinc, which have recently been made by Russian chemists, the principal result of the work being the demonstration of the highly favourable effect conferred by the addition of silver to the lead. The research workers have found that a lead-silver anode, with a silver content of 2·5 per cent., has a stability for the process twenty to twenty-five times greater than that of pure lead anodes. The favourable effects of the silver are revealed with additions of as low as 0·5 per cent. The value of these lead-silver alloys was found to be uninfluenced by considerable percentages of impurities, and it was also discovered that antimony up to 0·5 per cent., arsenic up to 0·5 per cent., bismuth up to 0·2 per cent., or bismuth and arsenic together up to 0·4 per cent., had no harmful influence on the anodes. Further, the presence of zinc sulphate, manganese sulphate, and glue in the sulphuric acid electrolyte had no adverse effect on the anode.

DEALING with the subject of oil supplies in war in a recent paper, Colonel W. A. Bristow suggested that owing to the fact that this country is dependent upon foreign countries for its oil supplies, the danger of supplies being cut off might be overcome by the building of large underground storage depôts inland, well away from prominent landmarks. These depôts should be capable of holding a total of at least 5,000,000 tons, and should be connected with ports by pipe lines. In addition to the establishment of a national storage scheme, it would be of immense advantage if more oil were produced in this country. It was computed, said Colonel Bristow, that about 40,000,000 tons of raw coal were consumed each year for domestic purposes. All this could be replaced with smokeless fuel, to the general benefit of the nation. To make the necessary quantity of the smokeless fuel, it would probably be necessary to carbonise about 50,000,000 tons of coal. This would yield:—Smokeless fuel, 35 million tons; crude coal oil 900 million gallons; coal petrol, 150 million gallons; rich gas, 1500 million therms. The whole of the 900 million gallons of crude coal oil could be converted into petrol and/or fuel oil by hydrogenation. Alternatively, this oil could be distilled, yielding fuel oil, tar acids, pitch, and residues suitable for hydrogenation.

Air and Water.

ANOTHER flying boat of Imperial Airways has been damaged in Brindisi Harbour owing to the machine coming into contact with an Italian destroyer.

THE directors of the Cunard White Star Line announce that the commander of their fleet, Captain Sir Edgar Britten, R.D., R.N.R., now in command of the "Berengaria," has been appointed to the command of the "Queen Mary."

ACCORDING to the recently published performance figures of the new Gloster "Gladiator" fighting machines, shortly to go into service with the R.A.F., the top speed at 15,500ft. will be 260 m.p.h. The engines are of 685–715 h.p.

WITH a view to discussing such questions as manning, hours at sea, and paid holidays for seamen, a preparatory conference called by the International Labour Organisation has met at Geneva. The delegates represent countries owning some fifty million tons of the world's shipping.

A NEW type of forty-seater passenger aeroplane is being built in France. The design of the new machine is based upon the Farman "222" type of bombing aeroplane and will be the largest of its type yet constructed. It will probably be employed on the Paris-London and Paris-Marseilles routes.

DURING the first half of 1935 the scheduled air services in the United States set new safety records by flying 40,714,686 passenger miles for every fatality, says *Flight*. There were actually twenty-nine accidents, of which five were fatal, in the 28,729,128 miles flown, and a total of 377,339 passengers were carried.

IN connection with the establishment of a seaplane base as Greenock and following negotiations with the Clyde Pilotage Authority and the Clyde Lighthouses Trust, it has been decided by the Greenock Harbour Trustees to apply to the Ministry of Air for a Civil (Air) Aerodrome Licence in respect of the Great Harbour at the James Watt Dock.

SOME 2 tons of mail were carried by the Pan-American Airways machine "China Clipper" on the inaugural 8000-mile air mail service flight from Alameda, California, to Manila, Philippine Islands. It covered the journey to Hawaii in 21 hours 5 minutes. A sister machine will leave Alameda on December 6th and it is then intended to maintain a fortnightly service for mails and passengers.

PROVISIONAL arrangements have been made for the "Queen Mary" to leave the Clyde on May 24th next for Southampton, where she will arrive on the 26th. There she will be docked in the King George V graving dock for cleaning and painting of the underwater portion of the hull and final adjustment of the propellers. When this work is completed the vessel will proceed to sea for her trials.

IT is officially announced that the Air Navigation School at Andover and the Navigation School at Calshot will move to Manston by January 6th, 1936, and re-form on that date as the School of Air Navigation. The School will undertake the conduct of all air navigation courses. It will also be responsible for the air navigation and reconnaissance training of pilots for the general reconnaissance and flying boat squadrons.

IT is announced by the Southern Railway that the new cross-Channel train and motor car ferry service between Dover and Dunkirk will begin running next year. The service will be maintained by the vessels "Hampton Ferry," "Twickenham Ferry," and "Shepperton Ferry," and the locks to enable the vessels to link up with the shores on level terms at any state of the tide was therefore adopted, and these locks are now being constructed at the ports of Dover and Dunkirk.

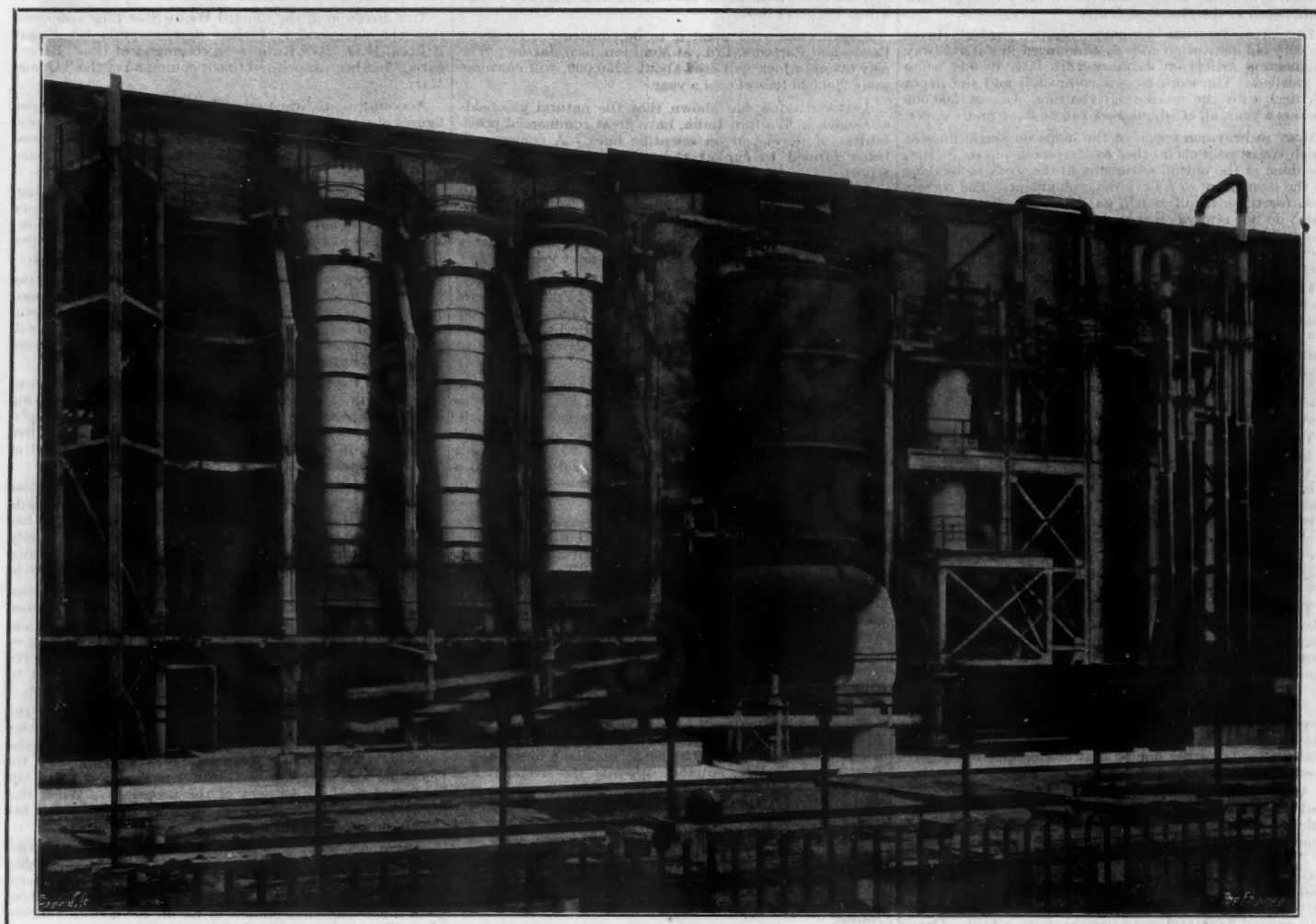
ACCORDING to the air correspondent of the *Daily Telegraph*, a new process of hardening the wood of aeroplane propeller blades and preserving them from changes arising from atmospheric conditions has been adopted in this country. This process, which is covered by a German patent, comprises the reinforcement of the leading edge of the blade by a narrow brass sheath soldered to a strip of gauze. The propeller is then covered with a sheet of celluloid, which is forced into the wood under pressure.

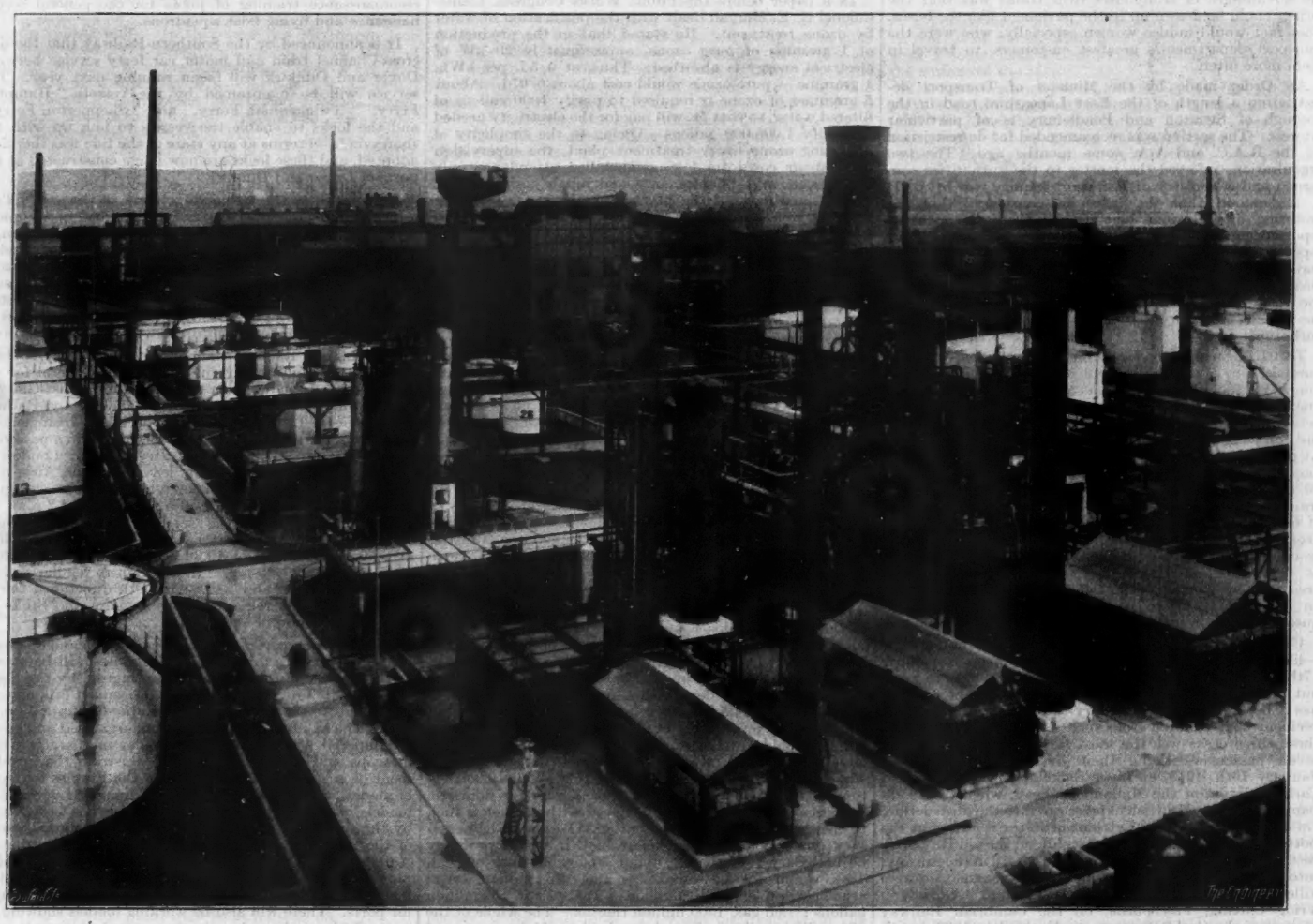
THE L.M.S. Railway announce that they have been awarded the contract by the Postmaster-General for the conveyance of air mails on their London-Belfast-Glasgow route, which is operated on their behalf by Railway Air Services, Ltd. As a result of these arrangements alterations are to be made to the services from a passenger point of view. The morning service from London to Belfast and Glasgow will now leave Croydon Airport at 9.30 a.m. instead of 9.45 a.m., arriving Belfast at 12.35 p.m. and Glasgow (Renfrew) at 1.40 p.m. instead of 2 p.m. In the reverse direction the service will leave Glasgow (Renfrew) at 7.50 a.m. instead of 9.15 a.m. and at Belfast at 8.55 a.m. instead of 10.30 a.m., arriving Croydon at noon instead of 1.35 p.m. In addition to regular calls at Liverpool (Speke) and Belfast in both directions, the air liners will call on request at Birmingham and Stoke-on-Trent northbound or southbound.

AN exhibition portraying the organisation and operation of the air services over Empire air routes will be opened at the Science Museum, South Kensington, by the Secretary of State for Air on Thursday, December 5th, and will be on view to the public from December 6th until January 31st. The exhibition, which is being organised and staged by Imperial Airways, Ltd., is popular in character, both in scope and treatment, and will illustrate the development of air communications within the Empire by means of models, charts, maps, and photographs. It will include models of every type of air liner which has been owned by the company since its inception, and sectional models of the new air liners which are now under construction. A part of the exhibition will be devoted to the design of air ports and will include a large model of a modern combined land and air port, and dioramas of three famous Empire air ports. There will also be working models showing the part which wireless plays in the control of aircraft when flying in fog or above cloud. There will also be sections devoted to the building of a flying boat and a land machine and to aero-engines.

THE I.C.I. COAL HYDROGENATION PLANT AT BILLINGHAM

(For description see page 576.)





ABOVE:—GENERAL ARRANGEMENT OF HYDROGENATION STALL
BELOW:—GENERAL VIEW OF DISTILLATION PLANT

The Engineer

NOVEMBER 29, 1935.

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NOTICES TO READERS.

*** *If any Subscriber abroad should receive* THE ENGINEER *in an imperfect or mutilated condition, he will oblige by giving prompt information of the fact to the Publisher, with the name of the Agent through whom the paper is obtained. Such inconvenience, if suffered, can be remedied by obtaining the paper direct from this office.*

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*** *All letters intended for insertion in* THE ENGINEER *or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

*** *No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.*

CHANGES OF ADDRESS.

*** *Will subscribers please note that in all advices regarding changes of address it is necessary to have* both the old and new addresses, *as our lists are kept alphabetically by towns. Advices of this nature should reach us by the first post Wednesday morning prior to the alteration.*

CREEP IN METALS.

SINCE 1922, in which year general attention was called to the subject in this country and in France, the existence of "creep" in metals subjected, at elevated temperatures, to prolonged stress has received an ever-increasing amount of consideration from investigators and designers. Of the importance of the subject there can be no doubt. With the advent of high pressure, high temperature steam power plant it has become a decisive factor in the design of steam turbines, boilers, piping and so forth, while outside the field of prime movers it enters prominently into the design of various forms of industrial plant such as that used for the hydrogenation of coal and similar processes demanding the union of high pressures with high temperatures. In the early days of the study of the phenomenon of creep, and indeed until quite recently, there appeared to be no great difficulty in designing plant on a basis making allowance for the existence of creep. It was commonly believed—and the belief was founded on what seemed to be good experimental evidence—that if the stress applied to a particular metal at a particular temperature were less than a certain value, the "limiting creep stress" for the metal at that temperature, the metal would not creep. On this basis the designer of a machine or appliance intended to withstand prolonged stress at an elevated temperature could, it seemed, ensure that each part would permanently withstand the load applied to it by taking care that the stress in it was less than the appropriate limiting creep stress. The only practical difficulty encountered lay in the fact that the limiting creep stress might be uncomfortably low with the result that when a reasonable factor of safety was superimposed on it, the required scantlings of the part might be objectionably large. The existence of a "limiting creep stress" seems to have had no other origin than the inability of the early experimenters to detect creep below a limiting value. With experimental equipment of an increasingly refined design the limiting creep stress was pushed lower and lower. To-day opinion favours the view that if a limiting creep stress exists at all it is so low that it cannot be used as a rational basis of design. In effect, therefore, we may say that under prolonged stress at an elevated temperature metals exhibit creep no matter how low the stress may be. It is even believed that at customary atmospheric temperatures metals under prolonged stress creep at stresses less than that corresponding to the so-called yield point but that the rate at which it takes place is so slow that it may for all practical purposes be neglected.

The abolition of belief in the existence of a limiting creep stress, in the strict sense in which that term was originally used, has undoubtedly complicated the task of the designer of high temperature plant. It has indeed wrought a complete change both in his methods and his aim. He now knows that it is impracticable to design his parts on lines enabling them permanently to withstand the stresses applied to them. The most that he can do is to design them to withstand their stresses for an acceptable length of time; that is to say for a prescribed life, the end of which is deemed to occur when the part has crept to a postulated degree. The amount of creep which may be tolerated varies with the duty of the part and its relationship to the duties of associated parts. It is the designer's task to ensure that the maximum tolerable creep shall not be manifested before the end of the pre-assigned life of the part has been reached. As examples, representative of current practice, the designer of a turbine disc may be required to ensure that at the end of 100,000 hours—or 11¼ years—the magnification of dimensions resulting from creep shall not exceed one ten-thousandth part of an inch per inch, while the designer of a superheater may be called upon to ensure that at the end of 20,000 hours the tubes shall not have crept by more than one-fiftieth part of an inch per inch. For parts subjected to stress at temperatures within the atmospheric range the traditional method of design is still acceptable for, although creep is probably existent at such temperatures, its rate is so very slow that the lives of the parts will be determined not by it but by other factors such as wear, corrosion or obsolescence of the complete machine or appliance. For the design of parts subjected to stress at elevated temperatures, however, safety requires the transference of the design procedure on to the new basis. That transference demands new knowledge on the part of the designer. Consider the information which he must possess in order that he may fulfil his task with assurance. If the prescribed life of the part is, let us say, 11¼ years, then strictly he, or someone for him, ought to subject samples of the metal, maintained at the specified working temperature, to a series of different stresses for a period of 11¼ years. At the end of that time he ought to measure the creeps exhibited by the samples and select for design purposes that stress which produced a creep strain equal to, or less than, the pre-assigned tolerable limit. Any procedure short of this programme will involve him in assumptions concerning the truth of which there is at present little enough experimental evidence. Even in carrying out the programme as described he will commit himself to an assumption unless his test specimens are exact duplicates in form and dimensions of the part with which he is concerned; it is believed that creep test results are largely independent of the shape and size of the test specimens but the point has by no means been completely established. Quite apart from this feature it is obvious that the test programme as described is an intolerable one because it involves testing a number of specimens for an unconscionable length of time. Considered by itself the number of specimens required might be reduced, possibly down to two, if the law connecting the stress applied to the metal at a given temperature and the creep thereby induced at the end of a given time were definitely known. With the aid of such a law it would be possible from the measured creeps produced by two known stresses to find by extrapolation the stress which would just produce the specified tolerable creep at the end of 11¼ years. The same law could also be used to affect some shortening of the test period for it would enable us to forecast from observations made at a relatively early date the creeps which the specimens would show at the end of 11¼ years. For reasons, however, which are obvious when we look at a typical creep-time curve the shortening of the test period by this procedure would still leave it unduly long; the form of the curve in its earlier stage is unsatisfactory as a basis for accurate extrapolation. An alternative method of shortening the test period would be carry out the test at some temperature considerably higher than the intended working temperature. The higher the temperature the more quickly does the metal creep but the exact law by which the creep exhibited in a given time is related to the temperature to which the metal is exposed would have to be known before this method could be usefully adopted. It would appear that the relationship of creep to temperature involves metallurgical as well as physical considerations. The exposure of a metal for a prolonged period to an elevated temperature—even to the relatively low temperatures found in "high temperature" steam plant—induces a change in the micrographic structure of the metal and such change is known materially to affect the creep-resisting characteristics. Until stability of structure is reached the change produced in a given time varies with the temperature. Hence unless the law governing the structural change produced in a given time by a given temperature is known with fair exactitude a short-period, high-temperature creep test may yield results which are thoroughly misleading when used as a basis of forecasting the behaviour of the same metal when exposed to a lower temperature for a longer period.

Possessing exact knowledge on all the points which we have mentioned the designer would still find in many cases that additional information was required before he could proceed with his task. The tests on which his knowledge was based would most likely be of the usual type in which the specimens throughout the test period are subjected to a constant tensile load. In numerous practical instances, however, the load on parts exposed to creep conditions is not constant. We are not now referring to the difficult problem of creep under cyclically varying stress but to the fact that under a static load a part may, by virtue of the creep which occurs in it, be subjected to a diminishing stress. For example a bolted flange may initially be pulled up tight, the force applied to the nuts inducing a certain amount of elastic strain in the bolts. Under this initial load the metal of the bolts will begin to creep, the elastic strain will diminish and the load applied by the nuts to the bolts will fall off. Since the creep and the initial elastic strain are of the same order of magnitude the ultimate condition arrived at would be a complete release of the bolts from all load. Hence after some interval the nuts would require to be retightened. So far as the designer is concerned a problem of this nature requires for its solution a knowledge of the creep of metals under diminishing loads and a knowledge of their behaviour when they are reloaded after a previous creep period. Apart from this point of constancy or diminution in the applied load the designer has to take cognisance of the fact that his knowledge is based on experiments confined to tests under simple tensile loads. Instances in which such knowledge can be directly applied in practice are rare. As in the case of parts subjected to static non-creep producing loads, parts exposed to creep conditions are commonly called upon to bear a compound distribution of load such as internal pressure and torsion—or bending—as in a steam pipe or such as the highly complex loading found in a rotating disc. It is essential for the designer to know in what manner the creep produced by one part of the loading, say the internal pressure in a steam pipe, affects the creep caused by the other, such as the bending moment arising from the thermal expansion of the pipe. It is obvious that in this aspect of creep the guidance provided by established theories of elastic strain under compound stress cannot be of material assistance.

We have now surveyed some of the main features of the phenomenon of creep in metals as it affects practical designing. It remains only to add that at a meeting of the Institution of Mechanical Engineers held in London on November 22nd Mr. R. W. Bailey of the Metropolitan-Vickers Electrical Company presented a paper, entitled "The Utilisation of Creep Test Data in Engineering Design," which is claimed to provide a rational basis for the design of parts required to operate under creep conditions and under any system of stress. The paper, in itself a very extensive one, must be studied in conjunction with certain earlier accounts of Mr. Bailey's investigations into creep, notably his paper "Testing of Materials for Service in High-temperature Steam Plant" presented before the same Institution in 1932. While fully agreeing with the unanimous opinion expressed by all who took part in the discussion last Friday evening that Mr. Bailey's latest paper is one of the greatest practical importance and value we feel that many designers would give it a still more cordial welcome if it were recast in such a way as

to co-ordinate it with the author's previous contributions and present in the simplest possible and most easily followed manner the established facts of the phenomenon as they are now understood.

The Highway and the Motorway.

In an address delivered last month before the Manchester and District Association of the Institution of Civil Engineers, Mr. G. E. Ashforth, elected Chairman of the Association for the present session, discussed British highway problems in respect of both administration and engineering, and compared, as measures providing for traffic on trunk routes, the construction of motorways with, as the alternative, consistent widening to the new standard requirements. Since proposals for the adoption of comprehensive measures, even if relating to trunk roads only, constitute road planning, whether the new feature of the system be one added to it or be the result of extensive alteration of existing roads, it is of some importance that the relation of road planning to the development of a road system be clearly understood. In that regard, Mr. Ashforth's observation, that a basic characteristic of our roads is "want of plan," though it is one often made in the course of such addresses, seems to be, in its implication of insufficiency of the system, somewhat misleading. In the earliest historic times, prehistoric tracks were used as through routes and villages were linked by similar ways. Except where provided in order to establish and maintain military control of a country, main road systems are not imposed upon, but grow out of, networks formed, by early track making, unless the country be a wilderness methodically being developed. The Roman road system in Britain was, accordingly, but an interlude in our highway history, leaving a dwindling legacy of main routes some of which are once more important roads. When wheeled vehicles were adopted for travel, the tracks were gradually transformed into carriageways, and since the ban on motor vehicles was removed, changes in the character of the carriageway surfacings have sufficed in respect of rates of wear and immunity from damage to the road or the vehicle. No radical change was then contemplated by the highway authorities, nor any fresh provision; but it is to be observed that, while the introduction of vehicles travelling at speeds up to 20 miles an hour involved driving at or in relation to speeds hardly double those ordinarily attained with fast-trotting horses, motor cars are now habitually driven at average speeds about twice and at full speeds on straight roads 3½ times the early limit for mechanical vehicles. As regards a very considerable proportion of local and the more slowly driven touring vehicles, the disparity is not much less. Evolution may, therefore, fail to meet the abruptly changed conditions and planning be necessary. Up to the present the attempt has been made to meet the requirements of traffic by widening and otherwise improving a large mileage of roads, and by constructing by-passes and a few new roads. Proposals for the construction of speedways on the lines of Mr. H. G. Wells' anticipatory description, in 1901, of "specialised ways restricted to swift traffic," were put forward early in the motor era, and specific schemes and estimates have since, from time to time, been prepared.

We have now reached, it may be believed, a stage in traffic development at which, even if existing conditions only be considered, there is a call for planning more comprehensive than that involved in the trunk road scheme or the new "push," and with more liberal roadway provisions. A first decision is required in regard to the question whether, in view of speed disparity and other factors, adequate provision can be made and reasonable safety assured by alteration, at any cost not prohibitory, of existing roads; or whether, on the other hand, resort must be had to the provision of separate ways, designated as for high-speed vehicles, or as motorways for long-distance travel. The most interesting passages in Mr. Ashforth's address relate to this problem. First and foremost, he remarks upon the significance of speed in relation to the frequency of road accidents, observing: "It can, I think, be said with truth that the fundamental reason is the use of the King's Highway as a track for high-speed vehicles imposed upon the customary rights of free access and usage by the public." In conformity with the views of most advocates of speedways, he proposes that, beginning with the construction of a few such roads, where there is an established need for provision for long-distance transit, there might be contemplated future provisions tending to the development of a complete, though not very extensive, system of motorways. All crossings with highways would be bridged and connections so disposed that vehicles entering or leaving the motorway would not cross any of its lines of traffic. On such a road, he observes, "motors could travel with high speed, and therefore high transport efficiency, without danger to the general public." Discussing the new arterial roads in the London area, Mr. Ashforth remarks that their intersections with existing highways are points of delay and danger, and are difficult to control, and that in this and other respects the essentials of a safe, efficient motorway are lacking, albeit there is evidence that these roads fulfil a need. In the five years' scheme the programmes, far from final, of many individual counties are for works estimated to cost from one to three millions. It is evident, therefore, that if motorways are ever to be considered they ought to be considered now. As regards the new standards, 120ft. width between fences, dual carriageways, footways, and cycle paths, Mr. Ashforth observes that there would be little purpose in applying an enlarged standard to a particular road unless, ultimately, this would be done continuously, which would but create, he adds, a combination of motorway and public highway with its attendant disadvantages all conducive to accident.

Mr. Ashforth has defined the main issue in regard to traffic requirements and road safety, and he has usefully brought into comparison with a policy logically involved in measures now being taken throughout the country a quite different policy of new construction on land for the most part unoccupied by villages or hamlets. The exercise of a little imagination leads to the conclusion that to spread through traffic into the portions of the highway system near main routes would be to carry the disparity factor to a second and even a third degree. Further, since the widening of trunk roads to a width of 120ft. between fences provides only dual carriageways, the separation of traffic classes is limited to that afforded by the cycle paths. Therefore, in order to separate traffic, whether in respect of speed, or its character, one of two measures involving engineering works must, it seems, be adopted. If motorways were to be provided, a speed limit could be imposed on the highways, at least where the journey by an alternative route partly or wholly on a motorway would take not much more time. The cost of the motorway would, of course, depend upon the extent to which separation of passenger and goods vehicles was effected, as well as upon standards in respect of gradients and curves, which need not be luxuriously high. If the widening of trunk roads is to eliminate the disparity factor, the width would have to be about 160ft., to allow of twice-dual roads being provided. A third measure which, without separating traffic classes would reduce in a predetermined degree the disparity factor, is the imposition of a speed limit, an additional safety provision, recently suggested as one increasing the value of the overall limit, being further speed reduction as indicated by conspicuous signs near dangerous cross roads and turnings. It seems expedient that all three of these solutions of the problem should be given immediate consideration, and that engineering costs of the works involved by the first and second should be compared by making estimates for a county or region of neither very easy nor very difficult topography and with about average village and hamlet population.

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

FAST TRAINS.

Sir,—Mr. Loftus Allen says that the fastest advertised booking of trains between London and Birmingham in 1902 was 2 h., whereas now it is 1 h. 55 min. But if he will look at the article in The Engineer to which I referred he will see that though in 1902 the advertised time was 2 h., the actual timing was 1 h. 55 min. So, as I said before, we are now back just where we were thirty-three years ago. It is true that the trains to-day, for the convenience of the railway company, make intermediate stops; but to a passenger wishing to reach his destination as quickly as possible, the reason for stops is of no interest whatever; whether it is to drop passengers or to allow the guard to pick blackberries the delay is exactly the same.

Mr. Loftus Allen's reference to greater comfort is difficult to understand. In spite of the 50 per cent. increase in fares it is now quite common practice on British railways to squeeze six passengers into a first-class compartment of a corridor coach, although when corridor trains were being introduced forty years ago everybody recognised that a first-class compartment could only hold four. In my own view no compartment in a corridor coach can ever give the comfort, just as it can never give the privacy, of the precorridor first compartment which had three seats on one side, and two window seats, with a lavatory door between them, on the other. Provided with a suitable dinner basket a passenger in one of those old compartments had more real comfort than he can have in any British train to-day.

As to the weight of the trains, this, again, is a matter which does not interest a passenger in the least. From the passenger's point of view a continuous service of light trains, running at frequent intervals, is obviously the most convenient, and if the railway company, for its own purposes, prefers to concentrate the traffic into a few heavy units, the passenger's right to a first-rate service is in no way impaired. And if the present-day trains are heavier, consider the size and cost of modern locomotives and all the improvements that are now available. I remember the Euston-Birmingham trains when they were hauled by McConnell's "Bloomer" engines—contrast one of them with a "Royal Scot" or a "Silver Jubilee."

I note that Mr. Loftus Allen gives no explanation of the fact that the Great Western Company can run a really good train to Bristol, but cannot even maintain the timing of a generation ago on some of its trains to Birmingham.

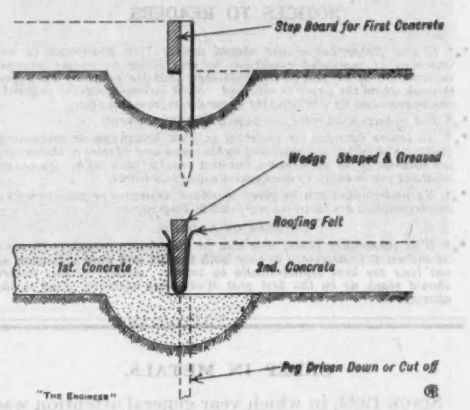
And, finally, I suggest that when comparing his London-Birmingham trains to-day with those of 1902, he should also compare the trains now running between other great business centres, such as Paris-Bordeaux, Berlin-Hamburg, New York-Chicago, or Chicago-St. Paul, with those running on the same lines in 1902.

London, S.W.1. November 22nd.

W. B. Thompson.

JOINTS AND CONCRETE PAVING.

Sir,—In your issue of November 15th you have a paragraph under the above heading. I might inform



you that I have always found the method given above satisfactory in building concrete roads and pavements.

Birmingham, November 19th. H. C. Johnson.

NEW *JOURNAL* OF THE "CIVILS": ADVERTISEMENTS.

Sir,—In perusing No. 1, *Journal* of the Institution of Civil Engineers, one is struck by the advertisements contained therein, and, moreover, it is noticed that all the advertisers are dependent upon the civil engineer for their existence.

There are at the moment many lesser chartered civil engineers, such as inspecting engineers, whose practice is wholly dependent upon their "greater professional brethren," who would greatly appreciate the privilege and benefit of advertising in the *Journal*. I wonder if "the Institution" will ever permit the "lesser professional brethren" to insert advertisements in their own *Journal*? This concession would be most beneficial to all concerned and could not be construed to be a breach of "professional etiquette," as it would only be advertising within the "civil engineering profession" itself.

Perhaps "the Institution" might be good enough to consider the above in their programme of modernisation.

Thos. A. Brown,
Assoc. M. Inst. C.E., A.M.I. Mech. E.

Wembley, November 22nd.

POWER FOR NOTHING.

Sir,—If we have 1 lb. of air at a pressure of 100 lb. abs. per square inch, and at a temperature of 5000 deg. Fah. abs. in the cylinder of an engine, and if we allow this air to expand adiabatically to the atmospheric pressure of 15 lb. abs., the engine, if perfect, will perform 279,300 foot-pounds of work. Similarly, if we have another engine the cylinder of which contains 1 lb. of air at 100 lb. pressure, but at 1000 deg. Fah., this engine will perform 55,860 foot-pounds of work in expanding its charge down to the same atmospheric pressure. From the 2 lb. of air we shall therefore obtain a maximum total of 335,160 foot-pounds of work.

Now, before the engines start, let us bring their cylinders

into contact so that heat may be conducted from one to the other until the temperatures of the air are equalised. If the engines are then set in motion, expanding the contents of their cylinders as before to the final pressure of 15 lb. abs., it will be found that one will perform 131,100 foot-pounds and the other 230,200 foot-pounds of work, making a total of 361,300 foot-pounds for the 2 lb. of air.

We have thus gained 26,140 foot-pounds of work, or nearly 8 per cent., without taking in any more outside heat. This gain has, in fact, been brought about merely by permitting a process of heat conduction which is generally abhorred as involving a thermo-dynamic loss.

It should be noted that the air is in all cases expanded down to the same final pressure, and then exhausted to atmosphere, after which, of course, it is not liable to any further manipulation.

For simplicity it has been assumed that the specific heat of air is constant, but that is not where the catch is.

November 26th. FELIX QUI POTUIT.

SIXTY YEARS AGO.

ON November 17th 1875 at the age of eighty-two after a very brief illness Charles Blacker Vignoles died at his country house near Southampton. To-day we remember his name by its association with the type of permanent way rail which he invented. With the construction of railways much of his professional career was concerned but he began life as a soldier rather than as an engineer. He fought with Wellington at Vittoria in 1813 and crossed the Pyrenees into France with the victorious British Army. In March 1814 he was present at Bergen-op-Zoom when that Dutch town was attacked by Sir Thomas Graham and the British forces were driven back with heavy loss by the French defenders. In or about 1822 he found himself back in England and already in some repute as an engineer. It was a time when fierce battles were being waged over sundry railway schemes and Vignoles soon became immersed in them. The Liverpool Committee, having lost the first Bill for the Liverpool and Manchester Railway ordered the preparation of new plans. Vignoles was engaged by Rennie to take charge of the fresh survey. That work was carried out against much opposition from many landowners. To prevent the engineers from completing their plans and sections a strict watch was imposed by day with the result that Vignoles was often obliged to make surveys and take levels by moonlight or torchlight. On one occasion he was arrested and charged with night poaching and trespassing. On that charge he was hailed before the great Mr. Bradshaw at Worsley Hall. Bradshaw was the trustee of the Duke of Bridgwater and as such had absolute control over the Duke's canals and estates. Naturally he objected to the construction of a rival system of transport but Vignoles found him less severe than he had been painted. Indeed the charge which led to his appearance before Bradshaw developed into a not unfriendly discourse out of which there subsequently came an amicable arrangement by which the Duke of Bridgwater's heirs took a thousand shares in the railway company and secured the right to nominate three of its directors. Later Vignoles was present at the Rainhill trials and on October 11th 1829 he attended the great banquet given to celebrate the official opening of the line. On that occasion he deputised for Telford in responding to the toast of the President and Institution of Civil Engineers. In his speech he gave vent to a prophecy concerning the effect which railways would have on future wars as a means for the rapid transport of men and artillery to any threatened point and a little later he foresaw the day when railways would carry coal to London and end the monopoly of sea transport then being exercised by the great Northern coal mine proprietors.

POLLUTION OF THE RIVER TEES.

IN a report issued on November 22nd as Water Pollution Research Technical Paper No. 5 by the Department of Scientific and Industrial Research, and published by the Stationery Office at a price of 9s., a detailed description is given of the results of a chemical and biological investigation of the estuary of the river Tees. This investigation, which has occupied a period of about four years, forms part of a comprehensive survey of the whole of the river and its tributaries from its source on Cross Fell in the Pennines down to the sea. Of the various industrial effluents discharged into the Tees, the most important are those from by-product coke works. The main toxic constituents of these effluents are cyanide and a group of phenolic substances known as tar acids. Approximately 2 tons of tar acids and nearly 1 ton of cyanide are contained in the average quantity of industrial effluent discharged each day. No other toxic substance enters the estuary in large quantities. Several methods of treatment of the effluents containing cyanide were examined. In experiments on a large scale by one method, 5000 gallons of effluent per hour were treated with lime and with waste liquid from local galvanising works. The untreated effluent in 1 per cent. dilution killed fish in a few minutes, whereas the treated effluent in the same dilution was innocuous over a period of twenty-four hours. As a result of the work relating to effluents from coke ovens, it has been concluded that the discharges of such effluents into the Tees could be greatly reduced in quantity, and possibly avoided, by modifications in the methods employed for cooling and washing coke-oven gas and by the utilisation of the waste liquids for quenching coke. It is understood that as a result of the investigation installations of coke ovens to be erected in the future in the Tees area will be so designed that appreciable quantities of polluting liquids need not be discharged. With regard to pollution of the estuary by sewage, this could be reduced by treatment of the sewage in efficient purification works, or by discharging the sewage into the sea at a point some distance from the shore.

Commercial Motor Transport Exhibition.

No IV.

(*Concluded from page 548, November 22nd.*)

CHASSIS AND VEHICLES.

IN this article we conclude our survey of the principal exhibits at the Twelfth International Commercial Transport Exhibition, arranged by the Society of Motor Manufacturers and Traders, which was held from November 7th to 16th at Olympia.

One of the most interesting exhibits in the Commercial Motor Show was probably the Bristol Axial engine, a full description of which was published in THE ENGINEER on May 24th last, page 545. The engine was shown in its production form, and is practically unchanged from the experimental model which we described, a tribute to the correctness of its design. We reproduce a front end view of the engine in Fig. 39. In addition, the Bristol display included two chassis in stripped form, and others fitted with bodies. The type J chassis has been designed to suit various power units, so that its performance can be varied to suit individual requirements. The engines that can be fitted are:—The "Bristol" type P W four-cylinder petrol engine, 4¼in. bore by 5½in. stroke, giving 76 b.h.p. at 2000 r.p.m., R.A.C. rating 32·4 h.p.; the "Bristol" type P W four-cylinder petrol engine, 4¼in. bore by 5½in. stroke, giving 90 b.h.p. at 2000 r.p.m., R.A.C. rating 36·1 h.p.; the "Bristol" type J W six-cylinder petrol engine, 105 mm. bore by 140 mm. stroke, giving 103 b.h.p. at 2000 r.p.m., R.A.C. rating 41 h.p.; the "Gardner" type 5 L W five-cylinder oil engine, 4¼in. bore by 6in. stroke, giving 85 b.h.p. at 1700 r.p.m., R.A.C. rating 36·5 h.p.; and the "Gardner" type 6 L W six-cylinder oil engine, 4¼in. bore by 6in. stroke, giving 102 b.h.p. at 1700 r.p.m., R.A.C. rating 43·5 h.p.

The transmission is by a single dry plate clutch to the overspeed gear-box, which incorporates a high gear, in addition to the direct top and three indirect lower gears. The advantage of this extra high top gear, besides permitting increased acceleration on the normal top gear in traffic, lies in the greatly reduced engine wear on long journeys with the decreased revolutions at which long runs are made. The modern high-efficiency engine is often run at unnecessarily high revolutions, when no great acceleration power is needed, and the overspeed gear avoids this. The selector gear fitted to the box avoids the disadvantage of a five-speed transmission, namely, the extra work demanded of the driver. Dewandre servo-assisted brakes and Bristol cam type spring anchorages are used, the latter providing a method of varying the spring strength according to the load on the chassis due to the position taken up by the springs. A 26-seater coach body of the Q5/26 Bristol type was shown mounted on this chassis, which has a load capacity of 4 tons and a wheel base of 17ft. 3½in.

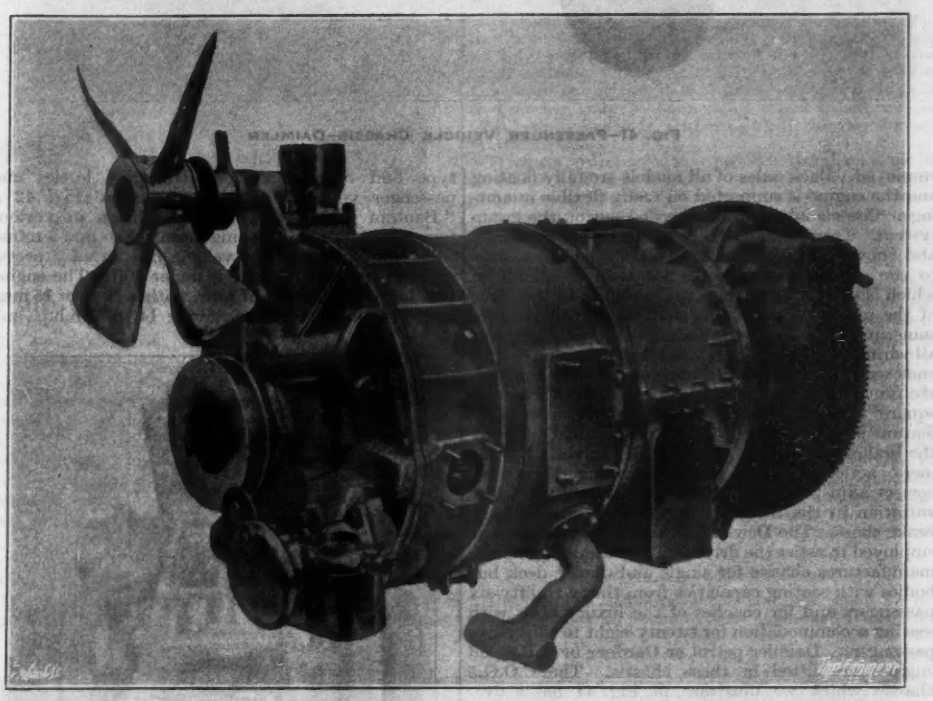


FIG. 39—AXIAL WOBBLE-PLATE ENGINE—BRISTOL TRAMWAYS AND CARRIAGE CO.

The type G chassis—see Fig. 40—has a load capacity of 6 tons 5 cwt., and a wheel base of 16ft. It is similar to the J type, except that the overspeed gear-box is an extra fitting, a four speed box with selector gear being standard. It is suitable for either a Bristol J W type six-cylinder petrol engine of 105 mm. bore by 140 mm. stroke, R.A.C. rating 41 h.p., and giving 103 b.h.p. at 2000 r.p.m., or the "Gardner" 5 L W five-cylinder oil engine of 4¼in. bore by 6in. stroke, rated at 36·5 h.p. and having an output of 85 b.h.p. at 1700 r.p.m., or the 6 L W "Gardner" of the same cylinder dimensions rated at 43·5 h.p. and giving 102 b.h.p. at 1700 r.p.m. A 48-seater "Bristol" double-deck omnibus body of the A M 9/48 type was also shown fitted on a model G chassis with a "Gardner" five-cylinder oil engine.

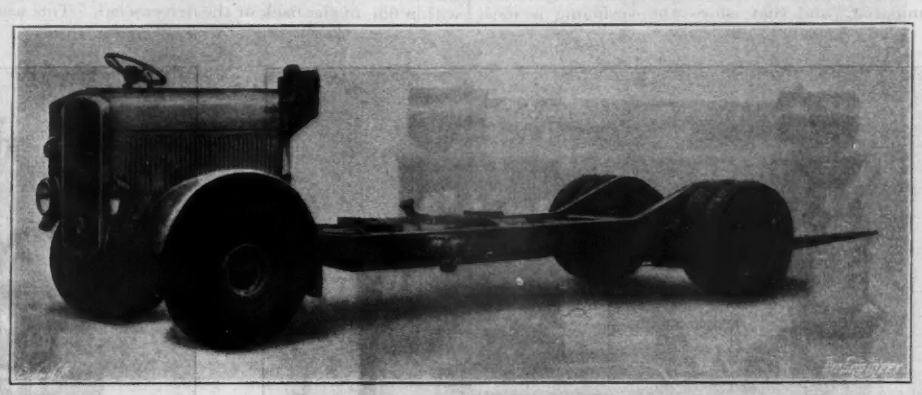


FIG. 40—6¼-TON CHASSIS—BRISTOL

In dealing with the exhibits of the Daimler Company, Ltd., of Coventry, it can at once be said that every chassis has a large number of features, in common with other chassis by the same makers. Of

course, there is the fluid fly-wheel and pre-selective gear-box, and the latter can in most cases have either four or five speeds to meet the requirements of the particular district in which the vehicle is to be employed. Back axles of all models are fully floating and the engine is supported on really flexible mountings. Chassis lubrication is carried out on the group system. Examination of the various chassis exhibited also showed that particular attention has been paid to the electrical wiring, the location of a fault in which is usually so difficult to discover. In the place of the mass of untidy wire and ill-protected cables sometimes to be seen, the Daimler Company arranges all wiring in dash conduits. Whilst the wiring is thus enclosed and protected, it is also made accessible by the provision of covers that can be removed from the square conduits. Another particularly interesting feature is that a system has been adopted whereby the brakes automatically adjust themselves. By the mere action of the driver applying them the correct adjustment is maintained irrespective of any variation in the rate of wear between the different brake shoes. The Dewandre vacuum servo system is employed to assist the driver. The Daimler Company manufactures chassis for single and double-deck bus bodies with seating capacities from thirty to fifty-six passengers and for coaches of the luxury class with seating accommodation for twenty-eight to thirty-five passengers. Daimler petrol or Gardner or A.E.C. oil engines are fitted in these chassis. The C.O.G.5 chassis, which we illustrate in Fig. 41 has a five-cylinder Gardner oil engine, a wheel base of 16ft. 3in., and a body space of 21ft. 4½in. Its particularly neat design is observable in the engraving.

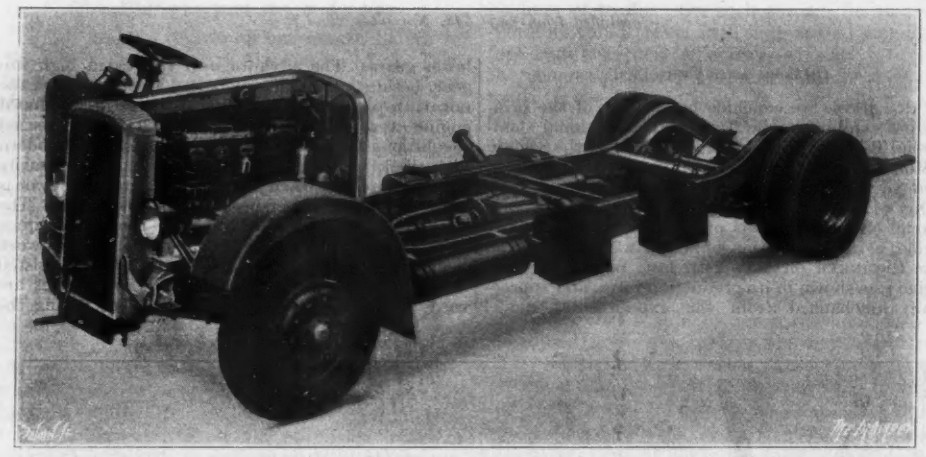


FIG. 41—PASSENGER VEHICLE CHASSIS—DAIMLER

The Eagle Engineering Company, Ltd., of Warwick, is, of course, well known for the trailers it manufactures. The most interesting of its exhibits at the Show was undoubtedly a two-wheel trailer with independently sprung axle. The upward pressure on the road wheel is carried, through cranked stub axles able to rotate in the tubular cross members, by springs which are compressed through the intervention of tension rods. It is claimed for this design, which, by the way, can, of course, be applied to any number of axles, that a saving of weight is effected; that distortion of the chassis frame and bodywork is eliminated, and that, since the springing is most sensitive when the cranks are horizontal and parallel with the ground line, the trailer is as well insulated from road shocks when running light as when laden.

Among the many vehicles shown on the stand of Karrier Motors, Ltd., of Luton, was a wide selection of six-wheel trollybuses in both chassis and completed forms, together with vehicles of the mechanical horse type and other inner-zone transport lorries and passenger vehicles. We illustrate in Fig. 42 a "Bantam" chassis, which was shown in various forms, such as a low-loading 2-ton tipper and a refuse collecting vehicle. The vehicle has an easy access cab and its turning circle is under 30ft. The engine is a four-cylinder petrol unit, with a bore of 75 mm. and a stroke of 110 mm., giving 14 to 47 b.h.p., and

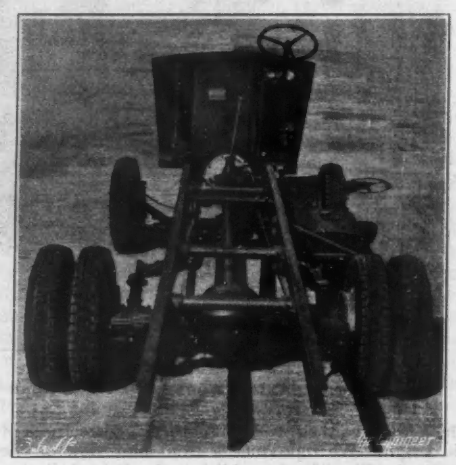


FIG. 42—BANTAM CHASSIS—KARRIER

a Treasury rating of 13·9 h.p. There are four-wheel brakes and the chassis weighs 23 cwt. The wheelbase is 7ft. 9in. and the track 5ft., and the tires are 25in. by 6in., with twins at the rear.

Among the new developments in six-wheeled vehicles were the Carrimore automatic retractor, which enables the front of the van to be brought within 6in. of the back of the driver's cab. This was shown by Carrimore Six-Wheeler, Ltd., of North Finchley. There was also a wide selection of vehicles by Morris Commercial Cars, Ltd., of Adderley Park, Birmingham; Clement Talbot, of London; and Commer Cars, Ltd., of Luton. Guy Motors, Ltd., of Wolverhampton, exhibited several examples of light and heavy chassis, with petrol and oil engines, an outstanding exhibit being the new 7½-ton oil engine chassis. A new series of Bedford models was shown for the first time by Vauxhall Motors, Ltd., of Luton. Trojan, Ltd., of Purley-way, Croydon, showed a chassis of the "Lowdall" 20–25-cwt. rear-engined commercial vehicle type, equipped with a six-cylinder, two-stroke engine. The floor of this vehicle is only 19in. from the ground, and loading is facilitated by the use of roller shutters on either side of the vehicle. A synchro-mesh gear-box is provided, and four-wheel brakes of the Girling type. A smaller 10-cwt. van, with a four-cylinder, two-stroke engine, and a two-speed epicyclic gear-box and worm drive, was also on view.

Arran Motors, Ltd., of Welwyn Garden City, exhibited several examples of lorry chassis, engined with Perkins and Gardner oil engines. The Maudslay Motor Company, Ltd., of Coventry, was represented by a bus and goods vehicles, and the Hobbs transmission was shown on the stand and demonstrated in a coach outside Olympia.

A new range of commercial vehicles was exhibited by Fodens, Ltd., of Sandbach, Cheshire. Taskers of Andover (1932), Ltd., showed trailers and timber carriage vehicles embodying new features, and E. R. Foden and Son, of Sandbach, Cheshire, had on view a range of chassis and vehicles fitted with Gardner oil engines. Among the tank vehicles we may mention several excellent examples of light alloy construction shown by the Duramin Engineering Company, Ltd., of Willesden, and the Aluminium Plant and Vessel Company, Ltd., of Wandsworth. One of the exhibits on the stand of this firm was a 1200-gallon, four-compartment tank, with patented syphonic discharge.

SOME NEW OIL ENGINES.

This year's Exhibition was outstanding for the advance recorded in British high-speed oil engine design. Some of the leading British and foreign designs have been described in preceding articles, and in this connection we would state that the 175 b.h.p. Henschel-Lanova engine referred to on page 547 of our last issue is an eight-cylinder unit and not a six-cylinder one. A wide range of oil engines was shown by Beardmore Diesels, Ltd., of 36, Victoria-street, London, and Dalmuir, Dumbartonshire. We illustrate in Fig. 43 the six-cylinder, 100 b.h.p. engine, which has a bore of 4¼in. and a stroke of 6in. and runs at 2000 normal r.p.m. It has a Treasury rating of 43·3 h.p., and weighs about 1406 lb., complete with the starting motor, dynamo, and brake exhauster, as shown in our illustration. The unit is arranged with an open fly-wheel suited for coupling to a separate type gear-box. Another engine of the same pattern was shown in section to illustrate working parts, and it may be recalled that a similar Beardmore six-cylinder engine was awarded a prize in the International Diesel Engine Contest held in Russia last year. Other exhibits on this stand included a four-cylinder 65 b.h.p. unit, and a range of component parts. Fig. 44 shows the new Gardner 4 L K engine of 3·8-litre capacity, which, after two years of careful experiment, has recently been put on the market by Norris, Henty and Gardners, Ltd., of London and Patricroft, for light vehicle work. The engine embodies the firm's latest practice, and is extremely compact in design and small in overall dimensions. It only weighs 575 lb. bare and 684 lb. complete with starting motor and light fly-wheel. The cylinder dimensions are 3¼in. bore and 5¼in. stroke, and the rated b.h.p., which is only 65 per cent. of the maximum h.p., is 53 at 2000 r.p.m. The Treasury rating is 22·5 h.p. A very good fuel consumption is obtained. It

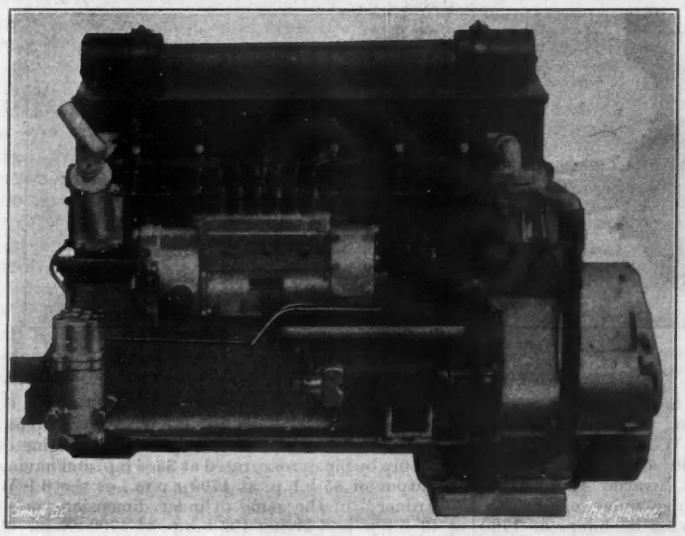


FIG. 43—100 B.H.P. OIL ENGINE—BEARDMORE

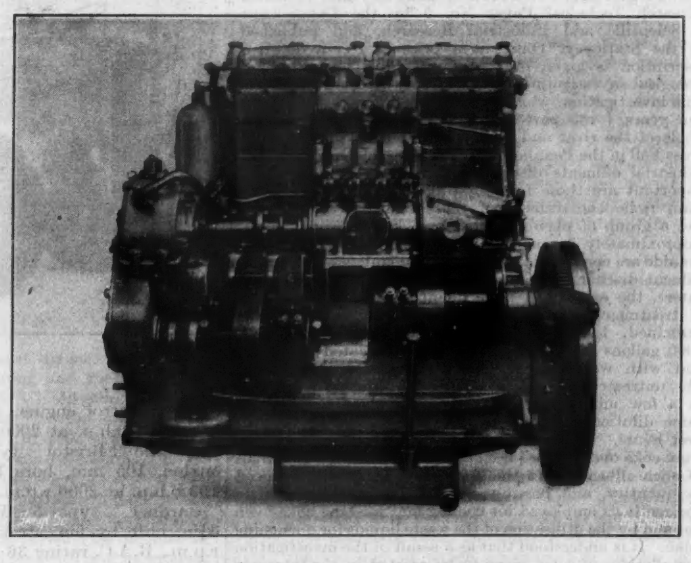


FIG. 44—53 B.H.P. OIL ENGINE—GARDNER

works out at 0·370 lb. per b.h.p. hour at 1000 r.p.m. up to 0·380 lb. per b.h.p. hour at 2000 r.p.m. It is claimed that for a given weight or volume of fuel the new L K engine will propel a vehicle from two to three times the distance of a petrol-engined vehicle. Features in design include the use of aluminium cylinder heads, with a reversible valve seat construction, an aluminium alloy four-cylinder block with renewable dry liners of hardened material, and an electron main crank case with through-going ball construction. The embodiment of the air intake

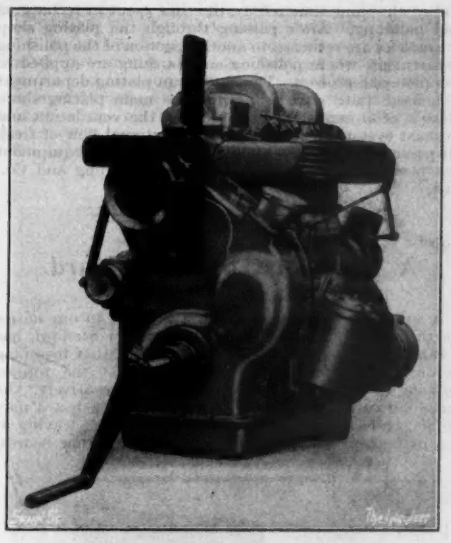


FIG. 45—OIL ENGINE—PERKINS

passage in the cylinder head cover makes a very neat arrangement. Our engraving clearly shows the grouping of the various auxiliaries and pumps. The Gardner engines included, besides the unit we have described, other four, five, and six-cylinder engines.

In Fig. 45 we illustrate one of the Perkins range of oil engines, designed and manufactured by F. Perkins, Ltd., of Peterborough. There are three four-cylinder engines in this range, the "Wolf," an 85 mm. bore, 120 mm. stroke engine, of 18 to 45 b.h.p.; the "Lynx," a 100 mm. bore, 127 mm. stroke engine, of 24 to 54 b.h.p.; and the "Leopard," an engine with 100 mm. bore and 127 mm. stroke, giving a 24 to 60 b.h.p. range of output. These engines can be employed on vehicles for pay loads of 2½ tons up to 5 tons, and have achieved remarkable running results. They are noteworthy for their light weight per b.h.p., which is 616 lb. for the "Leopard" engine, giving a peak load output of 60 b.h.p. at 2400 r.p.m. The "Wolf" engine recently recorded six speed records in the 3-litre Diesel class at Brooklands, and a special feature of this performance was the wide speed range from 300 up to 4000 r.p.m., although for general lorry work a governed speed of 2400 r.p.m. is adopted. Brief reference may also be made to a new six-cylinder Saurer engine—see Fig. 46—which was exhibited on the Armstrong-Saurer stand. It has a designed output of 72 b.h.p. at 3000 r.p.m., with a bore of 80 mm., a stroke of 120 mm., and a capacity of 3·617 litres, the Treasury rating being 23·8 h.p. The dual turbulence system of combustion is used with a special annular atomiser and a Saurer fuel pump with hydraulic control. This new engine gives a weight to power ratio of 9½ lb. per b.h.p. in full running order. Other oil engines included the Mercédès Benz, the Cummins engine, and the Meadows-Lanova engine.

AUXILIARY APPLIANCES.

An exhibit of outstanding interest in the auxiliary section was the new Tyresoling process, which was demonstrated by Henry Simon, Ltd., of Cheadle Heath, Stockport, which firm has recently opened a London depot at Dukes-road, Western-avenue, W.3, for the retreading of tires on the tire soles system.

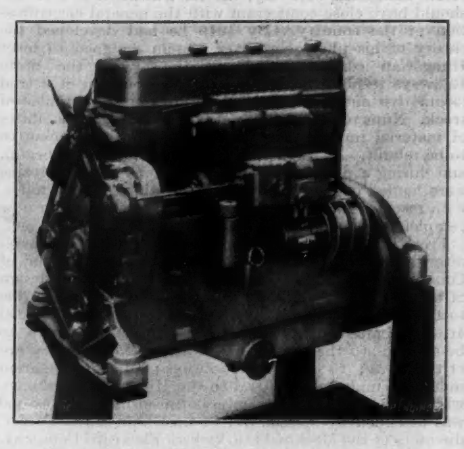


FIG. 46—72 B.H.P. OIL ENGINE—ARMSTRONG-SAURER

Fig. 47 shows three principal steps in the sequence of operations employed. Tires which are worn but in good condition are first of all mounted on a spreader and are carefully examined in order to ascertain whether the casing is sound and fit to stand another tread. If passed in inspection, the surface of the worn tire is lightly buffed in order to level, clean, and roughen the crown. As the left-hand view shows, the new tread which consists of a plain strip of best quality rubber, is then applied to the crown. A further mounting on the stretcher then takes place—see the centre view, Fig. 47—which allows a curing ring to be slipped over, after which the new tread is vulcanised to the crown of the tire by admitting steam to the tubes forming part of the curing ring. This process is shown in our right-hand view. After the correct curing time, the tire is again returned to the spreader, and the curing ring slipped off, leaving the new tread with the sides of the tire untouched and the cords undamaged. The finished tread is of the latest non-skid pattern, and it is claimed that the Tyresole process will give a new tire mileage over again at half the cost of new tires, while if not badly worn the same tire can be retreaded more than once. This process has been, we understand, tested in practice, both in America and England, and it should constitute an important factor in the economics of road transport.

FIG. 47—TYRESOLING :—APPLYING NEW TREAD —— FITTING THE RING —— VULCANISING

A CEMENT and Concrete Association has been formed to function as the service and research organisation of the industry and to undertake work of a propaganda nature.

Modern Ways of Burning Solid Fuel.*

By P. O. ROBERTS.

THE longer one is engaged in the coal trade the more one realises how much there is to learn about coal, its widely varying properties, and their application, and how little is actually known. It is composed of few elements, and it is rather odd that a small difference in their proportions may cause a fundamental difference in the more important characteristics of the composite substance. The most marked is probably the variation in volatile matter on which is based the three main divisions of anthracite with about 4 per cent. to about 9 per cent.; semi-bituminous with about 9 per cent. to about 20 per cent., and bituminous about 20 per cent. to about 45 per cent., and even more in a few cases. The individual coals falling within each category are readily recognised, not only by their analyses, but by the effect of the application of heat, and even by their appearance and physical structure. The distinctions are, however, less obvious within any one group, and an actual trial of any one bituminous coal is considered essential before an assessment of its comparative characteristics can be made.

This method of trial is, however, satisfactory only up to a point; its value must be limited by number of coals actually seen being consumed and the capacity of the observer to make the right deductions. On this basis knowledge of the reactions of different bituminous coals to heat can only be learned by actual experience, or from hearsay evidence, neither of which may be of great practical value.

It seems reasonable to conclude, therefore, that if means can be devised whereby some of the more important properties of different bituminous coals can be deduced from sources readily available to all, the information so derived will be dependable and complete, and will help to bridge the present gulf between the experienced and the inexperienced.

Probably the greatest difficulties confronting the vendor of industrial fuel are those of determining the extent to which any particular bituminous coal is likely to emit smoke, and its capacity to coke, cake, or be free-burning when used for steam raising, and the purpose of this paper is to introduce and explain methods by means of which these properties may be ascertained from the analyses. That the knowledge is of practical value, as distinct from purely academic interest, is evidenced by the fact that new business is frequently lost, owing to the fuel recommended for test being unsuitable in one or more of these respects. Further, smoke regulations are becoming more strict in urban areas, and knowledge of the extent to which any particular bituminous coal is likely to give smoke in different circumstances is of great importance.

SOME FACTORS OF COMBUSTION.

Although the series of chemical reactions called "combustion" appear to be simple, they are actually extremely complex, particularly as regards the burning of the volatile matter. What happens when bituminous coal is burnt is not known in detail, but only those factors which affect the matter under consideration will be discussed, and those briefly.

Assume a bed of incandescent fuel on the grate of a boiler furnace on to which a fresh charge of bituminous coal is thrown by hand. The temperature is rapidly reduced by the heat absorbed by the green coal and its distillates, and by the cold air entering the fire-door, and the amount of heat so used depends mainly on the weight of the new charge and its percentage contents of volatile matter and moisture. Almost immediately, *i.e.*, when the new coal is heated to about 150 deg. Cent. (302 deg. Fah.) to 200 deg. Cent. (392 deg. Fah.), the volatile matter begins to be distilled off, the quantity increasing rapidly as the temperature rises. There is, therefore, a very large volume of combustible gases released into the furnace during a short period of time.

* Excerpt from a paper presented at the First National Coal Convention, London, November 21st.

and this is particularly the case when slacks or small graded sizes are used.

This volatile matter provides a substantial part of the total available heat, sometimes more and sometimes less than an equal weight of carbon according to the particular coal. From the heating point of view alone, therefore, it is important that the volatile matter should be completely burnt; for this three conditions are essential:

(1) There must be a suitable admixture of an appropriate amount of air. (The oxygen of the air provided under the grate is virtually consumed during its passage through the fuel bed, so that the oxygen necessary to burn the volatile matter must enter through the front and/or sides of the furnace.)

(2) A continuing temperature sufficiently high for the volatile matter to ignite and burn.

(3) It must be maintained at this minimum temperature for such time as may be required for complete combustion.

Smoke.

If any of the above requirements are not provided in full, a greater or less proportion of the volatile matter will escape unburnt up the chimney in the form of a brown (not a black) smoke with some loss of efficiency. With cylindrical boilers (vertical, Lancashire, Cornish, and so on) the first two conditions may be provided, but the third is limited by the small combustion space, and, when hand-fired (even by the coking method), some of the combustible gases pass into the flue unburnt.

Black smoke is different, and arises mainly from the "cracking" (decomposition) of some of the volatile hydro-carbons causing very minute particles of unburnt carbon to be present in the flue gases. This separation of free carbon occurs when the volatile matter is insufficiently or incompletely mixed with air and submitted to a high temperature immediately after distillation, and when the temperature of the burning gases is reduced to some extent when their combustion is checked by coming into contact with the comparatively cool surfaces of the boiler.

These adverse conditions are again found after replenishing hand-fired cylindrical boilers where there is the combination of a small combustion chamber, and a rapid emission of a very large volume of combustible gases which cannot be properly mixed with the necessary air. Some reduction in smoke can be obtained by leaving the furnace door partly open for a short time after firing, or fitting it with suitable slots through which the air can pass freely over the fire when required.

Relation Between Coking Property and Smoke.

It is rather important to understand how the extent of black smoke emission is associated with the particular type of bituminous coal being burnt, and how it can be reduced and even eliminated.

The gases distilled off cover a series from the heavier tarry vapours to the light hydro-carbons, and the larger the proportion of the former type the more likely is black smoke to be emitted. These heavy vapours are less stable than the lighter types, do not burn as easily, do not readily become intimately mixed with air, and are more likely to be decomposed with separation of free carbon when submitted to a high temperature immediately after being driven off. This heavy type of hydro-carbon is in greatest proportion when coking coals are being burnt, gradually reducing through caking qualities, and at the minimum with free-burning sorts, so the liability to cause black smoke decreases from coking to free-burning bituminous coals.

The tendency to give black smoke is dependent on the quality of the volatile matter, and is not by any means directly proportionate to the percentage volatile content of the coal.

Automatic Stoking.

Irrespective of the type of bituminous coal being burnt, it will now be clear that, in order to reduce black smoke, it is necessary:

(1) So to add fresh coal that the temperature of the incandescent fuel bed is not unduly reduced, and that the volatile matter is driven off slowly, and at as low a temperature as possible.

(2) To ensure that there is intimate and efficient admixture of air as the gases are distilled off.

The provision of these conditions is the basic principle of mechanical stokers. The green coal is admitted slowly and continuously in such a way that the volatile matter is distilled off and burnt in a manner which is least favourable to the emission of black smoke.

The Hungarian State Railways.

As far back as 1924 Professor L. Verebély described in The Engineer the outstanding features of the Kando system of railway electrification, which has since been put into service in Hungary. In our issues of January 6th and 13th, 1933, we published articles on the equipment, and on February 10th of the same year a leading article dealing with the scheme generally. By reason of the fact that Hungary is the only country in the world that is using 50-cycle, single-phase current for traction purposes, the undertaking is of exceptional interest, and it is satisfactory to learn from notes sent to us by the Metropolitan-Vickers Electrical Company, Ltd., on the inaugural festival on July 24th last, that the equipment manufactured in part by that company is meeting expectations. The original contracts placed in April, 1931, provided for the supply of four locomotives, which were delivered in May and June of 1932. By September 12th, 1932, the first 60 miles of the railway were fully equipped, and on that date the first locomotive was put into regular service. The second 60 miles of the railway were put into service on October 23rd, 1934. Service tests of the first four Metrovick locomotives having met all expectations, work on the balance of twenty-two engines was begun in April, 1933, and completed in the same month of the year following. After a few days' trials and the prescribed acceptance runs, they were put into scheduled service, and have proved thoroughly reliable and otherwise satisfactory in operation. Similarly, the sub-stations and overhead equipment are said to have left nothing to be desired.

On the day of the festival of inauguration, Dr. Otto Senn, President of the Hungarian State Railways, received at the Budapest East Station many distinguished guests, and at 8.40 a.m. the entire party left by a special train drawn by a decorated locomotive. At the power station and sub-station at Bánhida, Professor Verebély addressed the party on the power station. Vice-President Lahner, of the State Railways, then reviewed the history of the electrification scheme, and explained that in 1917 the late Dr. Kalman de Kando pointed out that to secure all-round maximum economy, the electrification of railways should have close connection with the general electrification of the country. By 1919 he had developed the theory of his phase converter system designed to meet Hungarian conditions. Negotiations with the State Railways resulted in starting the construction of a trial locomotive and the electrical equipment of 29 miles of track. Numerous trial runs naturally revealed possibilities of material improvements which caused the locomotive to be rebuilt. In August, 1928, further tests were begun, and during a period of two years various kinds of trains were hauled over a total distance of about 39,100 miles, with results that led to the scheme of electrification now completed.

From Bánhida the train took the party to Györ, where, after luncheon, Mr. Géza Bornemisza, the Minister of Commerce of Hungary, explained that while the design of the system was entirely Hungarian, thanks were due to the British Government for assistance in the financial arrangements which made it possible for the work to be started; to the British manufacturers for their share of the work; to the State Railways; to the Hungarian industrial undertakings, and to the Hungarian workmen, who co-operated with patriotic enthusiasm. The festival was attended by Messrs. W. C. Lush and P. S. Turner, directors of the Metropolitan-Vickers Electrical Company, who also paid tribute to the Hungarian engineering staff and workmen. Ganz and Co., the Hungarian electrical contractors, were represented by the general manager and deputy managing director.

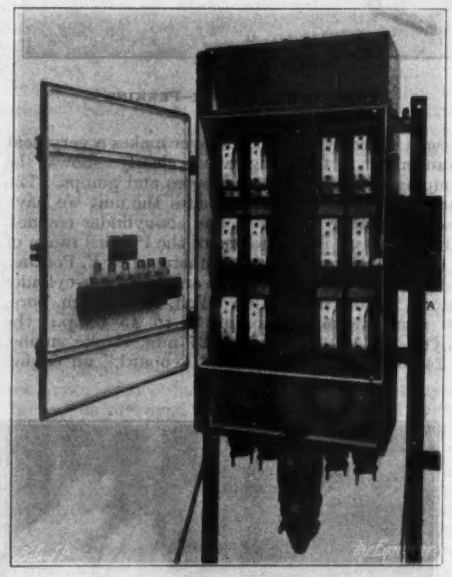
A Modern Electro-Plating Plant.

Three years ago, James Neill and Co. (Sheffield), Ltd., installed plant for electro-plating the numerous parts used in the manufacture of their "Eclipse" hack saw frames, 48 tools, "Red Ring" razors, permanent magnets, and other products. This installation included equipment required for silver, nickel, copper, and cadmium plating, but the demands made upon the plant were so great that it was found necessary to establish a new self-contained department, equipped with additional plant working under modern factory conditions. Included in the new equipment is a chromium plating plant. The extension adjoins the company's steel warehouse and research laboratories and has separate sections for polishing and preparation, general plating and chromium plating, together with a control section which combines plating, laboratory, and administrative office. The power, heating, and ventilating plant is housed separately in the basement to prevent the deterioration of the electrical generating equipment by the plating fumes and to facilitate maintenance without interference with other processes.

A feature of the new building is the treatment of the walls, girders, and ceilings with metallic paint, which not only gives a high light reflection with even diffusion, but also ensures cleanliness and affords protection against the steam and fumes which are associated with electro-plating. The floors are drained and treated with an acid-resisting protective coating. Particular attention has been paid to the glazing and ventilation of the department. The main part of the building is arranged to house two separate sections, which provide a progressive cycle of operations for the electro-deposition of metals. The work enters the polishing and preparation section, at one end of which glazing and buffing is undertaken before the parts are passed into the general plating shop, where, after being subjected to chemical and electrolytic cleaning, they are plated. Numerous baths are employed for the deposition of silver, copper, cadmium, and nickel, and it is interesting to note that the last-named metal is deposited direct upon the steel base without a primary coating of copper. Agitation equipment in the vats is provided where necessary to assist the plating operation, and timing apparatus is installed to ensure uniform results. The question of temperature control has received special attention and a dual system of heating and ventilation has been installed by which room temperature can be regulated to a close degree throughout the whole of the year. For ease in plating the various small irregularly shaped parts special suspenders or jigs have been designed so that the vats will accommodate the maximum number and at the same time reduce the time spent in recharging and handling. After passing through the plating shop the articles are returned to another section of the polishing department, where polishing and finishing are applied to complete the process. The chromium plating department is housed quite separately from the main plating shop. Here special care has been taken in the ventilation and exhaust system so that there is a continual flow of fresh air passing through the room at all times. The equipment has been supplied throughout by W. Canning and Co., Ltd.

A New Distribution Board.

A new fused distribution board brought to our notice by the English Electric Company, Ltd., of Stafford, has a cable connector chamber at each end so that incoming or outgoing cables may be brought in at the top or bottom of the board as required. Alternatively, the incoming cables may enter at the side. The board may obviously be used on a ring main entering or leaving at top or bottom and, in addition to feeding other boards,



Distribution Board

tappings taken through the side openings may supply other gear. Long cable tails are unnecessary, the outgoing contacts being connected to Poxolin-covered copper rods, which, after passing through an insulated spreader, terminate at each end in a clamp-type sweating socket. Another special feature is a push-off spring indicated at A in the accompanying illustration. This ensures that the door cannot be left partially opened. If it is not definitely closed and fastened the spring forces it wide open, and there can be no doubt about the condition in which it has been left. Owing to the construction of

General Plating Shop at the Works of James Neill and Co.

the catch handles, the door is pressed firmly against the housing, and damp and moisture are excluded by a hemp packing.

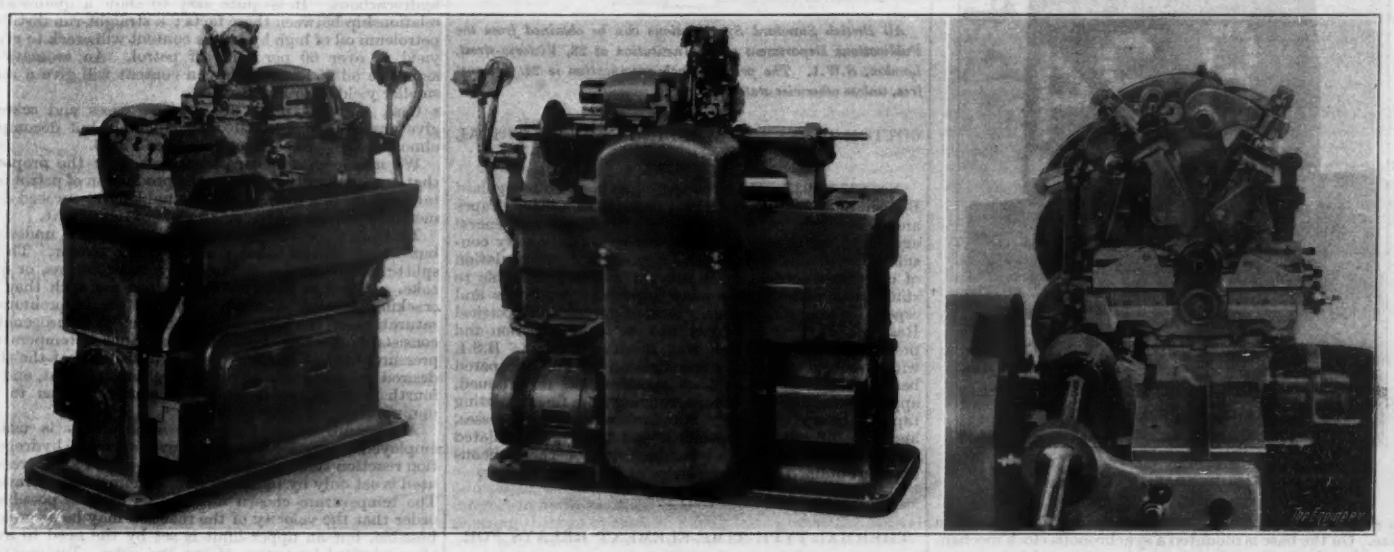
A Small High-speed Precision Automatic.

THERE has just been put on the market by A. C. Wickman, Ltd., of Coventry, the 10 mm. high-speed precision automatic illustrated by the accompanying engravings. The tool is of all-British manufacture by Bryant Symons and Co., Ltd., of London, and is designed to be suitable for such work as the production of pinions for clocks and meters, screws, and various parts for the wireless and electrical trades. Particular attention has been paid to the simplicity and ease of setting up, and type of tools used, and the design is such that full use can be made of the cutting capacity of the new high-speed cutting alloys.

The machine can be driven either by electric motor or by belt from overhead shafting. In either case vee ropes carry the power to the main driving shaft, and nests of three pulleys give three spindle speeds. From the main driving shaft spiral gears transmit the drive to the feed-box for the cam shaft. From the gear-box the drive passes through pick-off gears to a shaft at the rear of the machine, on which is fitted a two-step vee pulley and thence to an intermediate shaft fitted with a five-step V pulley before passing through a worm and wheel to the cam shaft. Changes in the feed cycle are obtained by changing either the pick-off gears or one of the belts. For each spindle speed there are available 117 changes of feed, ranging, over the complete spindle range, from 0·55 sec. to 4 min. 6 sec. When motor driven, the machine is arranged with stop and start push-buttons on the front. All operations are automatic, and one man can look after several machines.

The headstock is of the sliding type, and its movement is obtained from a plate cam on the cam shaft actuating a lever on which is fastened a roller operating on a block attached to the headstock casing. This roller centre is such that easy adjustment can be made to the ratio between the cam and headstock. For long work the sliding motion is obtained from a bell cam operating directly on to a roller on the end of the headstock casing, a weight fastened to the headstock by a chain operating the return motion. Chuck opening and closing is obtained by two dogs which require radial adjustment only irrespective of the length of the work or position of the headstock. There are four tool slides, each of which has a quick clamping device. Micrometer adjustment is available for setting the tools. Other details of the general design will be gathered from the engravings, while the following table gives some dimensions :—

Chuck capacity	0·390in. (10 mm.)
Maximum capacity for steel	10 mm.
Maximum capacity for brass	12 mm.
Maximum turning length, plate cam	2¾in.
Maximum turning length, bell cam	4in.
Number of spindle speeds	3
Range of spindle speeds, r.p.m.	8967, 6676 and 4520
Feed range	117 changes
Section of tools	⅝ in. sq.
H.p. of motor	1
Speed of motor, r.p.m.	1410
Net weight	15 cwt. (approx.)
Length (excluding stock carriers)	4ft.
Width	2ft. 3in.
Height	4ft. 2in.



10 MM. HIGH-SPEED PRECISION AUTOMATIC

Oil-Filled Factory Cables.

A 33-kV cable installation in the Liverpool factory of J. Bibby and Sons, Ltd., has been carried out by British Insulated Cables, Ltd., on unusual lines to meet rather unusual conditions. To reduce distribution losses arising from the expansion of load, a new 10,000 kVA sub-station was built on the factory roof in close proximity to the load centre, and current at 33 kV supplied by the Liverpool Corporation Electricity Department is transmitted to it from the old sub-station, which is in the same building block. Owing to the difficulty of taking the cables through the buildings, they are laid underground as far as the point below the new sub-station, and are then taken inside and cleated vertically. As the rise to the new sub-station is 140ft. and the voltage is high, it was decided to use oil-filled cables, which, needless to say, are not generally employed for factory work. Two circuits of three 0·1 square inch single-core, 33-kV, oil-filled cables, arranged in triangular formation, together with a twenty-core control cable, are run from the 33-kV switchgear in the old sub-station in Great Howard-street to the bus-bar end boxes in the switchgear in the new sub-station. From this point the supply is taken in four circuits of three 0·6 square inch cables, single-core, solid 33-kV cables, to four 2000 kVA transformers, which reduce the pressure from 33 kV to 400 volts.

Each 33-kV oil-filled cable was lashed at intervals to a wire hauling rope, and drawn up the building by means of a winch. When in position they were transferred to lashings on the studs of the cleats. When the third cable of each circuit was in place the cleats were fixed, the slack between floors being taken up by means of a pulley block and tackle. During the installation of the cable, the oil pressure was maintained by means of pressure tanks at the lower ends, and to balance the head due to the vertical rise and maintain the pressure above that of the atmosphere at the upper ends it was necessary to operate these tanks somewhat above their normal maximum pressure.

Cabling between the transformers and the low-voltage switchgear consists of four circuits, each composed of nine 1·25 square inch, single-core, paper-insulated, lead-covered, 600-volt cables. There are three cables per phase, and those installed indoors are finished with servings of compounded hessian tapes.

American Engineering News.

American Industrial Exhibitions.

RECENT exhibitions of machinery and industrial apparatus are indicative of a revival of trade and commercial activity in the United States. After an interval of three years, the usual annual special exhibits of railway materials and appliances were again in evidence at the 1935 annual meetings of the American Association of Railway Roadmasters (*i.e.*, Permanent Way Inspectors), and the American Association of Railway Superintendents of Bridges and Buildings. But two much larger and more general exhibitions have proved very successful. The first of these was the Machine Tool Exhibition, held at Cleveland for ten days in September, and visited by great crowds, which not only looked it over, but placed orders. It is stated that the exhibitors spent about £40,000 for floor space and service, but took orders aggregating more than £1,000,000. A majority of these orders was for machines of the new designs in style and operation, where results are making the old machine tools obsolete. The other large exhibition, held in Chicago for a week in September and October, was the National Metal Exposition. This was in connection with a group of meetings of the Institute of Metals, the American Society for Metals, the American Welding Society, and the American Institute of Mining and Metallurgical Engineers. An interesting exhibit was a working model of a plant for heat treatment of railway wheels. The travelling charging machine placed the wheel in the furnace, withdrew and carried it on to the quencher, and then the annealing furnace, and then the cooling pit. Special alloy steels were numerous, together with welding processes for various grades of steel, cast iron, aluminium, and copper. Among the several kinds of furnaces was the convection air-tempering gas furnace, and controlled atmosphere furnaces for heat treating and brazing without causing scale. In all there were over 200 exhibitors.

Oxygen Beneficiation for Blast-furnaces.

Increasing attention is being given by American metallurgists to the economic aspects of beneficiation of the air blast by the addition of oxygen to neutralise the effects of nitrogen. At a meeting of the American Institute of Mining and Metallurgical Engineers in October, it was pointed out that in making a ton of pig iron some 3 tons of inert nitrogen pass through the furnace, while 1½ tons more circulate with the products of combustion in the hot stoves. Thus an annual production of 40 million tons of pig iron involves 180 million tons of inert nitrogen. For every ton of oxygen in the air, 3½ tons of this inert nitrogen carry away heat to waste. It is considered quite practicable to reduce the nitrogen element to 80 million tons for the same annual output of pig iron. Furnace production can be increased without increasing the blast volume by reducing the nitrogen content and beneficiating the blast through liquefying part of the air and distilling off its nitrogen. This can be done economically, since plants producing large quantities of low-cost metallurgical oxygen are now available. Further, the hearth temperature produced with hot blast at 1250 deg. Fah. can be produced with beneficiated air blast at atmospheric temperature and produce the same weight of CO in the bosh with the same weight of coke per ton of pig iron. Economies resulting from this beneficiated blast are noted as follows :—(1) At the same temperature, reduction will be more active with richer bosh gas, increasing furnace production without an increase in furnace operating pay roll ; (2) it gives instantaneous furnace operation control through nitrogen control of bosh gas temperature, which is a factor of high importance ; (3) it eliminates sluggishness of the furnace due to a high moisture content in the blast ; (4) it eliminates the present cost of operation and maintenance of hot stoves ; (5) the furnace operates with cooler top gas ; (6) with nitrogen reduced the air temperature blast maintains hearth temperature and furnace heat requirements, so that there is no need of hot blast ; (7) the blast-furnace top gas not being used for hot stoves can be used to generate power for producing liquid air, with a production cost of 5d. per 1000 cubic feet of oxygen.

Power Transmission from Boulder Dam.

Of the fifteen 82,500 kVA water-power and generating units in the power station of the Boulder Dam on the Colorado River, four are assigned to furnish current to the Power and Light Department of the City of Los Angeles, 266 miles distant. This long transmission line traverses 226 miles of dry, rough, semi-desert country, having three mountain ranges, and subject to extremely heavy rainstorms. Here the cables are carried by single-circuit towers. For the remaining 40 miles, through a farming area and thickly settled suburban district, double-circuit towers are used. Two circuits of 287 kV were adopted, being 17 per cent. more economical than three of 220 kV, while for 330 kV the large conductor diameter and increased cost were estimated to be highly uneconomical. Two intermediate switching stations, about 90 miles apart, divide the line into equal thirds and increase the power limit to such an extent as to justify the two stations rather than one. All the towers have an average spacing of 1000ft., and the conductor cables have a minimum clearance of 27ft. above the ground. At 60 deg. temperature the normal tension is 4370 lb. on the conductors and 1800 lb. on the ground wire. After tests of several special forms of conductors the adopted design is a hollow cable formed of ten interlocking copper segments, making a conductor 1¼in. in diameter, with 512,000 circular mils of copper area. Its weight is only 1½ lb. per foot, so much lighter than others as to effect a saving of 12 per cent. in cost of the towers. Owing to its special interlocking construction, it has no greater amplitude of vibration than the heavier cables tested. The single-circuit towers are 110ft. high, with diverging arms from the 62ft. level, a 75ft. cross arm extending across the fork at 90ft. above the ground. The double-circuit towers are 145ft. high, with three 40ft. cross arms 25ft. apart, the lowest being 75ft. above the ground. The conductor cables are carried by 10ft. strings of suspension insulators, the length being determined largely by the assumed effects of lightning striking the tower or the overhead ground wires.

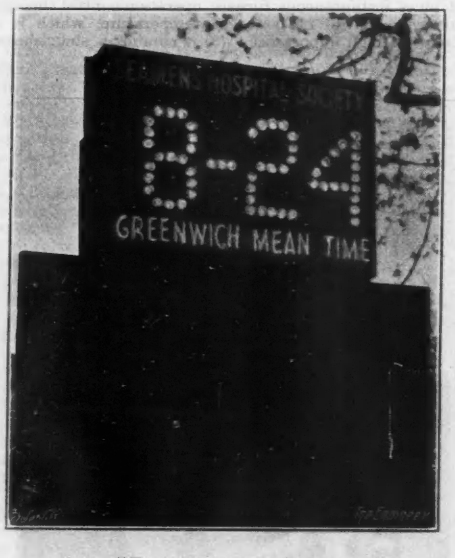
IN a recent debate on "Road Regulations" at the Manchester Athenæum, Mr. F. W. Hatton, Secretary of the North-Western Area of the Automobile Association, said that human error was the main cause of accidents and every class of road user had a proportionate responsibility. Legislation had its uses, but it could be strongly argued that the way to reduce accidents lay far more in the direction of education in "road sense" than in the passing of laws to penalise the person after he had done the wrong thing.

An Electric Sign Clock.

A VERY ingenious adaptation of an electric sign of the "newspaper" type to form a public timekeeper has recently been produced by the Sign Construction Company, Ltd. The object of the designers was to give a large indication with a minimum of mechanism, and this has been done by employing three panels of electric lamps, suitable groups of these being switched in to form the desired figures under the control of a contact maker, which is, in turn, governed by a synchronous clock.

The "Figuregraph," as these clocks are called, which is illustrated is that erected at Greenwich for the Seamen's Hospital Society, and the three sections which make up the complete time panel are each provided with thirty-five sign type lamps.

The controller which actuates the switching of the lamps



"FIGUREGRAPH" CLOCK

is shown in the second illustration, and is quite small in size. On the base is mounted a synchronous clock mechanism A, which at each minute completes the operating circuit of a relay B and starts up the fractional horse-power motor C. This then operates through a belt and an enclosed worm reduction gear D and rotates the disc E. As this turns a small ball bearing, mounted after the manner of a crank pin, engages with one of the curved notches in the rim of the star wheel F, stepping it one space. As the star wheel turns, it moves its attached contact drum and changes the connections to the lamps of the right-hand division of the figure panel. The result is, of course, to cause the next figure in sequence to be displayed.

This first star wheel and contact barrel is divided up into ten sections and indicates the single minutes. Attached to the face of the wheel is an arm, terminating in a second ball bearing, and at each complete rotation of the barrel this arm actuates a second star wheel which has six sections. By this means the second contact barrel, indicating the tens of minutes, will be stepped round one division each time the first barrel moves from the "9" to the "0" position.

An identical arrangement causes the stepping of the "hour" contact barrel at each sixtieth minute, the third star wheel having twelve sections and an appropriately divided contact barrel for the control of the lamps in the left-hand division of the panel.

Once the circuit of the driving motor has been closed by the relay, the motor continues to run until the disc E has made a complete rotation, and as this occurs a suitable trip, attached to the disc, breaks the circuit, and the motor stops until the synchronous clock and relay again complete the circuit.

The synchronous clock is connected to the controlled frequency supply mains, and its accuracy of time-keeping is thus assured. The contact operating the relay is mounted on the wheel of the train, which rotates once per minute, and the motor provides ample power for making a reliable relay contact. The relay is of the enclosed mercury tube form, the "make" being by solenoid action and the "break" mechanical.

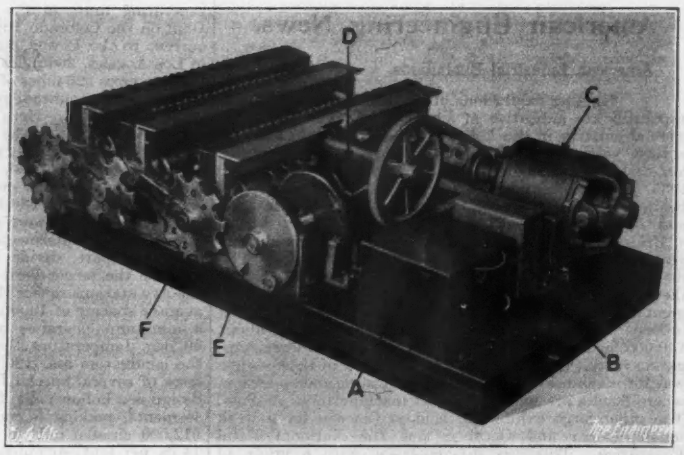
The motor driving the contact barrels is of the usual fractional horse-power type, and the worm gear runs in an oil bath. The contact barrels are of quite simple construction, and as it was realised that certain groups of lamps would always be displayed together, advantage was taken of this to reduce the number of circuits between the controller and the sign. Although each division of the panel contains thirty-five lamps, the number of circuit lines has been reduced to nineteen per unit by this method of grouping.

In the present instance the time control of the contact barrels is by a synchronous motor clock, but any timing device which made contacts at exact minute intervals could be used for control. Another feature of the mechanism is that quite a large sign can be operated without increasing the size of the controller to a proportionate extent, for as it only has to make contacts, its action does not call for any great mechanical effort.

The sign clock shown has special claim to notice in that it is erected exactly on the "0" meridian line at Greenwich. This site was chosen in order that the clock might be said to show true Greenwich time.

The relay consists of a mercury tube, pivoted out of balance, and so arranged that a solenoid, energised by the contact made by the synchronous clock, rocks it over, thus completing the driving motor circuit

The return of the mercury tube relay to the "off" position is operated mechanically, a trip arm being rocked by the disc, which is driven by the worm gear as it completes its rotation. The trip arm replaces the mercury tube in its original position, and then falls clear, leaving all ready for the next electrical "make."



CONTROLLER MECHANISM OF "FIGUREGRAPH"

BRITISH STANDARDS INSTITUTION.

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria-street, London, S.W.1. The price of each specification is 2s. 2d. post free, unless otherwise stated.

COTTON TAPES AND WEBBING FOR ELECTRICAL PURPOSES.

No. 633—1935. Hitherto there has been no recognised British Specification for the purchase of Cotton Tapes and Webbings for Electrical Purposes, and no general agreement on methods of test. In view of the very considerable use of these tapes and webbings for the insulation of coils for electrical machinery, it was felt desirable to standardise some of the more important properties and especially the dimensions. Accordingly, the Electrical Research Association looked into the whole question and prepared a report which was submitted to the B.S.I. with a request that a B.S. Specification should be prepared based on the report. That specification, now issued, applies to four classes of tape, ranging from fine insulating tape to heavy webbing. Standard widths, thicknesses, and sizes of rolls are specified, and tests are stipulated for tensile strength, and conductivity of the aqueous extract obtained by boiling strips of the tape in water.

THERMAL-TYPE TIME-ELEMENT RELAYS FOR RAILWAY SIGNALLING.

No. 635—1935. The seventh, and, for the time being, the final specification in the series of B.S. Specifications for Relays for Railway Signalling, has now been issued. The relays covered by the specification are intended to be used as auxiliary relays only, the coil being out of circuit on completion of the time intervals. The time delay between energisation of the relays and operation of the appropriate contacts is laid down as "at least five seconds at the maximum setting," and the voltage rating of the relays is limited to 30 volts. The portions of the specification dealing with constructional details follow the general lines of previous specifications in the series, but the performance requirements are of a special character.

AIR-DRYING INSULATING VARNISH FOR ELECTRICAL PURPOSES.

No. 634—1935. With a view to improving the properties of air-drying insulating varnish, the British Electrical and Allied Industrial Research Association recently carried out an extensive research and requested the B.S.I. to set up a committee to prepare a Specification for Air-drying Insulating Varnish based on the results of the E.R.A. research. The resulting specification recognises two types of air-drying insulating varnish: (1) Varnish with methylated spirit solvent, (2) varnish with non-alcoholic solvent. To comply with the specification varnish must satisfy specified tests for the following properties:—Percentage volatile matter, specific gravity, viscosity, drying time, electric strength in damp atmosphere, ageing and flash point.

The Development of Coal Hydrogenation.*

By KENNETH GORDON.

THE CHEMISTRY OF HYDROGENATION.

THE chemistry of the destructive hydrogenation process is now fairly well known, but the following summary, which does not pretend to be more than an approximate outline, is given for completeness.

The term covers three types of reaction which take place together. The first is the transformation of the impure carbonaceous material to a hydrocarbon, elements other than carbon and hydrogen being removed by combination with hydrogen. Oxygen thus forms water, nitrogen forms ammonia, and sulphur forms sulphuretted hydrogen.

The second type is the saturation with hydrogen of unsaturated bonds between carbon atoms.

The third type is the splitting of the saturated molecules so formed—see Fig. 1. It is only when a hydrocarbon molecule is relatively rich in hydrogen that it will decompose by heat treatment alone to give a high yield of light hydrocarbons. It is quite easy to show a quantitative relationship between these facts; a straight-run distillate petroleum oil of high hydrogen content will crack to give a yield of over 60 per cent. of petrol. An aromatic or asphaltic oil of lower hydrogen content will give a much smaller yield—see Fig. 2.

Coal, tar, and pitch are extreme cases and scarcely give any light oils at all upon cracking, but decompose almost entirely to coke and gas—see Fig. 3.

We may comment, in parenthesis, that the proposals that are frequently made for the production of petrol from tars and tar oils by cracking are unlikely to succeed commercially because of the small yield of light spirit.

There is a fourth type of reaction which is undesired, but which always takes place to some extent. This is splitting, not to light oil, but to hydrocarbon gas, or even coke. It occurs when the conditions are such that the cracking reaction takes place without proper preliminary saturation of the molecules. The art of hydrogenation consists in choosing the proper conditions of temperature, pressure, time of reaction and catalysis, so that the three desired reactions take place to the greatest extent, and the fourth reaction the undesired formation of gas to the minimum extent.

A pressure of at least 200 atmospheres is usually employed in practice in order to favour the coal hydrogenation reaction sufficiently. The upper limit to the pressure used is set only by technical and economic considerations. The temperature chosen must be as high as possible in order that the velocity of the reaction may be as great as possible, but an upper limit is set by the need to avoid the undesired formation of gas and coke. Temperatures used technically vary from a little over 300 deg. Cent. to over 500 deg. Cent. At the low temperatures the product is most saturated and the gas formation at its minimum. When the reaction takes place at high temperatures gas formation is greater and the product is more aromatic. Each feed material has its own optimum temperature limits and the reaction must be carefully controlled so that the temperature is always between those limits. Since the hydrogenation reaction is strongly exothermic, suitable means must be used to dissipate the heat of reaction. If the temperature is allowed to get high enough to give an increased formation of hydrocarbon gas, the temperatures tend to get out of hand, since this formation of gas is accompanied by still higher heat of reaction. Our design, however, gives absolute temperature control.

The catalysts used vary both with the raw material to be treated and with the product it is desired to make. Those usually employed accelerate both the hydrogenation and the cracking reactions, some accelerating both these reactions in a like degree, others the hydrogenation reaction in a higher degree, and others again tending more to accelerate cracking (or hydroforming).

For the production of petrol from coal, catalysts accelerating both reactions are used. The initial materials treated usually contain substances—for example, sulphur—which act as "poisons" on most catalysts. The removal of these "poisons" is for economic reasons not practical, and catalysts had therefore to be discovered which were immune to this "poisoning." This problem and the preparation of such catalysts has been solved with complete success by ourselves and the companies associated with us in the International Hydrogenation Patents Company (I.H.P.), especially the I.G. Farbenindustrie A.G., and it is largely by this development that hydrogenation was made economically possible.

The hydrogenation process takes place either in the liquid phase or in the vapour phase. The former is used for solids, or liquids of high boiling point. Hydrogen is passed continuously through the liquid material in which it is fortunately very soluble at the temperatures and pressures used. The catalyst for liquid phase reaction is generally introduced as a fine powder, which is kept suspended through agitation by the hydrogen. Solid coal is hydrogenated as a suspension in oil, similarly agitated.

The vapour phase reaction is used for the materials of lower boiling point, such as are formed in liquid phase reactions, and which are vaporised at reaction temperature. The vaporised oil is passed with hydrogen over suitably supported catalysts.

HISTORY OF HYDROGENATION.

We owe to Bergius the conception of the hydrogenation of coal to give oil. His experiments started before the war, and ended with a small technical plant at Rheinau, near Mannheim, which was in operation until 1927.

After the war the I.G. Farbenindustrie started work independently and brought to bear on the problem their great knowledge of high-pressure technique and of catalysts. They made two important advances: the discovery of catalysts immune to sulphur poisoning and the division of the hydrogenation process into liquid and vapour phase stages.

Developments in Germany then passed wholly into their hands and they built the first commercial hydrogenation

* The Institute of Fuel—November 22nd.

plant at Leuna in 1927. This was designed to produce 100,000 tons per year of petrol from brown coal, but at first it was operated mostly on low-temperature tar made from brown coal and on German crude petroleum. Experimental work was also done with bituminous coal. The applicability of the process to the petroleum industry was soon recognised and a joint company for its exploitation was formed by the I.G. and the Standard Oil Company (New Jersey). Two plants were built by the Standard

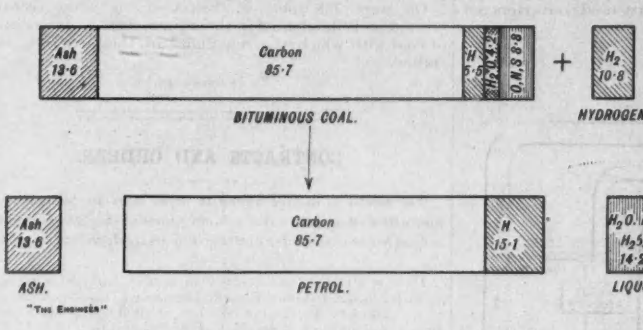


FIG. 1—*The Conversion of Coal to Petrol by Hydrogenation.*

Oil Company in America, which have been used for the production of petrol, special solvents, lubricating oils, and kerosene.

In the meanwhile the original Bergius process had been considered for British conditions, and tests on British coals were made at Rheinau. The I.C.I. decided that this process, worked in the original way to give a variety of products—petrol, tar acids, heavy oil, and pitch—was not profitable, but that it was more attractive if it could be modified to produce only petrol. It was decided also that the process must start with bituminous coal itself, since it was unlikely that tar, whether from low or high-temperature carbonisation, would ever be available in sufficient quantities to make any large proportion of the country's oil supply.

Experimental work at Billingham started early in 1927,

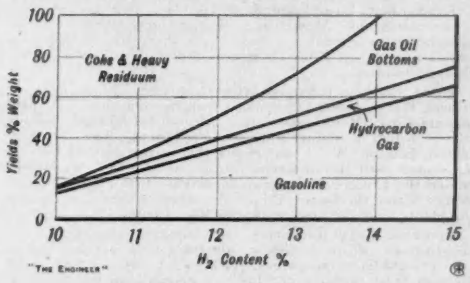


FIG. 2—*Cracking Influence of H_2 Content of Feed Stock on Yields.*

and in 1929 it was decided to build a pilot plant to treat 10 tons per day of coal. This plant was started up later in the same year and ran until the end of 1931. It was the first plant to hydrogenate bituminous coal on the scale of a commercial-sized unit for any prolonged period. Although, as was natural, many difficulties were found, none proved insuperable.

In 1930 the I.C.I. announced that they could produce a 60 per cent. weight yield of petrol from coal, and they gave estimated costs, showing that commercial development was possible only with Government assistance. Although many experts denied the possibility of such a large yield, the facts were satisfactorily demonstrated to officials of the Fuel Research Station delegated by the Government to inquire into the matter.

As the process developed the I.C.I. realised that although the original Bergius patents had lapsed there were many

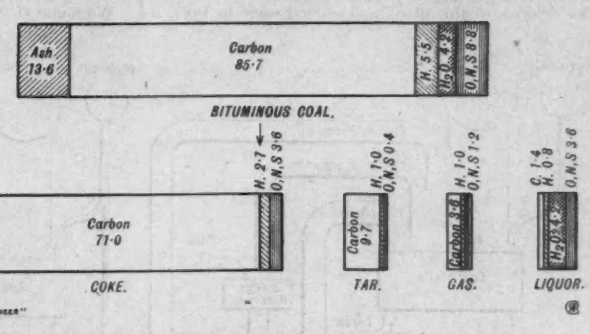


FIG. 3—*Low Temperature Carbonisation of Coal.*

important patents held by the Standard-I.G. group. Discussions were opened with this group, as a result of which in 1931 the four major operators in the field, namely, the I.G. of Germany, the Standard Oil Company (New Jersey), the Royal-Dutch-Shell group, and the I.C.I., associated themselves in a pooling company, the International Hydrogenation Patents Company, in order to pool their patent rights and to effect a general exchange of technical information the I.C.I.'s interests being centred in the

lated practical experience and technical resources as are possessed by the constituent companies in the I.H.P. pool.

In 1931 the I.G. resumed the hydrogenation of brown coal on a large scale, and this now provides the major part of the output of the hydrogenation plants in Germany. During 1932 the I.C.I. concentrated their hydrogenation research work on the treatment of bituminous coal, and were able to make several great advances in technique; at the end of the year schemes were prepared for building a large hydrogenation plant at Billingham.

In July, 1933, the Government announced their intention to guarantee the continuance of the preference on light oils made from indigenous materials for a period of years, by means of the British Hydrocarbon Oils Production Bill. This enabled the directors of the I.C.I. to decide to proceed with the erection of a plant at Billingham. The plant was to be ready early in 1935. Later it was agreed to take advantage to the extreme limit of the facilities available at Billingham and thus to increase the output of the plant by some 50 per cent. Tar oils, if available at a suitable price, were to be used as the raw material for this additional output, partly with a view to promoting the interest in hydrogenation of the carbonising industries and securing their co-operation, partly to minimise the capital cost, and partly because it was not desired to increase commitments on the then relatively untried process of coal hydrogenation.

In 1934 a large-scale experiment was carried out by the I.G. at Ludwigshafen on the hydrogenation of bituminous coal. The plant was operated for four months, and it was found that the process ran quite smoothly and successfully.

A large-scale plant at the Hibernia Colliery in the Ruhr is now decided on, to produce about 125,000 tons per year of petrol from bituminous coal. The hydrogenation plant at Leuna is extended to 325,000 tons per year output mainly by direct hydrogenation of brown coal, and two more plants are being erected in Germany, each of about 150,000 tons per year of petrol output.

I.C.I. Development and Research.

The interest in hydrogenation of the Department of Scientific and Industrial Research, and in particular of the Fuel Research Board at Greenwich, is well known. Credit is due to their early official recognition of the potential importance of the process to this country.

In 1927 I.C.I. acquired the British Bergius Syndicate and started independent research on the process. In 1930 they disclosed to the Fuel Research Board full details of the progress they had achieved.

Since then the Fuel Research Board has continued its work, and published many papers on its experiments. The I.C.I. have also continued their researches, but, as stated by Sir Harry McGowan in his recent speech in Billingham, on a greatly enlarged scale, and at a heavy annual cost. Since 1931, by reason of the arrangements with the International Hydrogenation Patents Company, we have published very few details of our work in the scientific literature. Its volume may, however, be realised from the fact that between 1927 and 1933 our expenditure on hydrogenation, including the construction and operation of a 10-ton a day pilot plant, amounted approximately to £1,000,000.

Apart from the fundamental discovery of coal hydrogenation, due to Dr. Bergius, the construction and operation of the present plant at Billingham is the development solely of our own research and experience, amplified by the research and experience of our associates in the International Hydrogenation Patents Company.

The first experimental equipment installed at Billingham was of the type used by Bergius which has been studiously copied by subsequent investigators. It is a small pressure autoclave working on the batch principle and heated externally by gas. In such apparatus the chemistry of the reaction was studied and numerous catalysts tried.

The pilot plant built by Bergius used stirred, externally heated, horizontal converters. Theoretical considerations led us to regard external heating on a large scale plant as unnecessary, because of the exothermicity of the

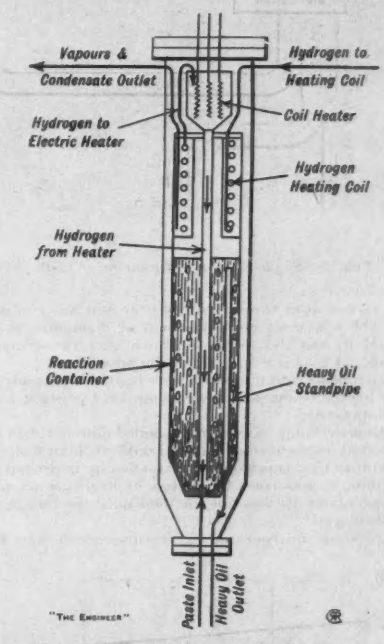


FIG. 5—*Experimental Plant Converter for Coal Hydrogenation.*

reaction. We also thought that by using a vertical reaction vessel of suitable shape, the stirring action of the hydrogen would enable mechanical stirring to be dispensed with.

A small-scale plant was built to test these principles, and in 1928 success was achieved. Three or four of these continuously operating coal hydrogenation plants have been working at Billingham ever since. Various sizes of reaction vessels have been employed, that now used being 20ft. high and 4in. in diameter. Although these experiments proved that on the large scale heating is unnecessary, on a small scale heat losses are so disproportionately severe that external heating must be applied. The converters must be made of special steel to withstand hydrogen attack—Fig. 4.

The second part of the research programme was the investigation of catalysts.

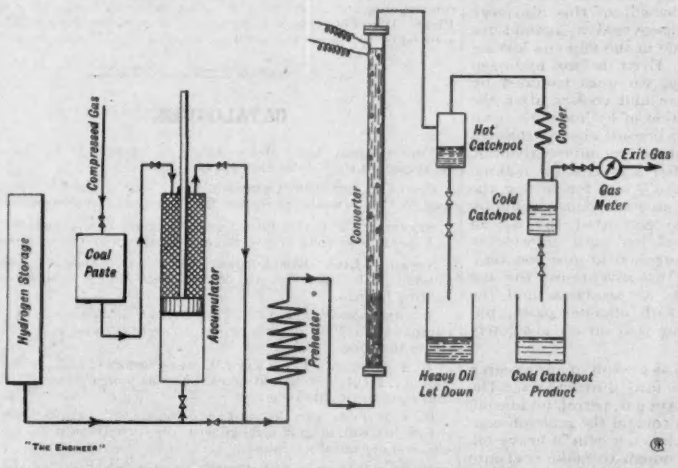


FIG. 4—*Diagram of Semi-Technical Coal Hydrogenation Unit.*

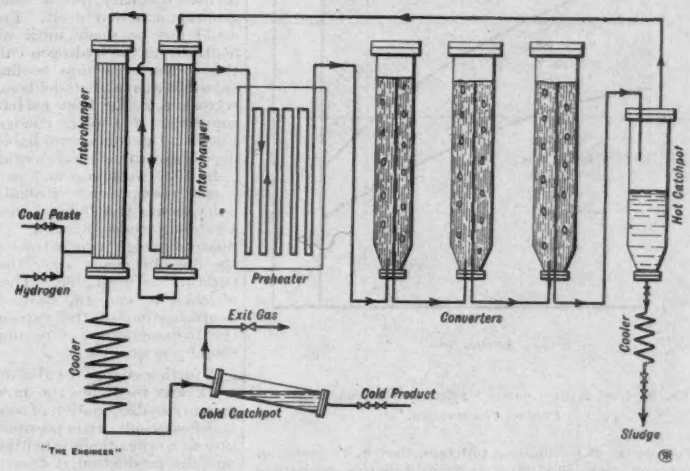


FIG. 6—*Diagram of Full-Scale Hydrogenation Unit.*

In 1929 we found that the most promising catalyst for the hydrogenation of bituminous coal was the element tin. We first intended to use it in the form of tinned iron plates, arranged as a grid. This arrangement, although practicable, was rapidly discarded in favour of a continuous injection of a very small amount of certain organic compounds of tin.

Immediately after this very important discovery, it was decided to erect a pilot plant at Billingham to hydrogenate 10 tons per day of bituminous coal.

The erection of this plant was started early in 1929, it was in operation at the end of the year and was run until 1931. The converter employed was of ingenious design, contrived to use the technique developed for ammonia synthesis. Fig. 5 is a diagram of the apparatus.

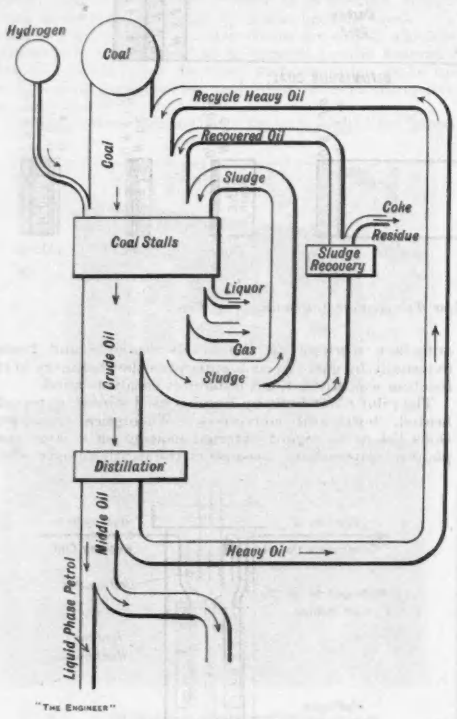


FIG. 7—*Single-Stage Hydrogenation of Coal.*

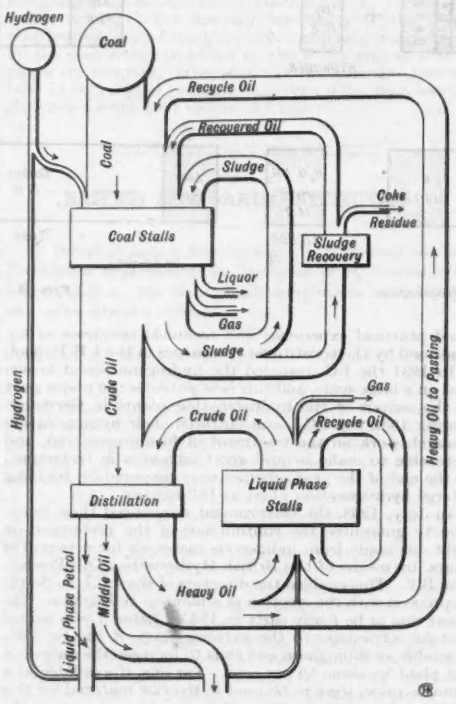


FIG. 9—*Double-Stage Hydrogenation of Coal.*

The coal paste and hydrogen were heated separately, an electric heater being used for raising the hydrogen to its final temperature.

The heat exchangers were of the coiled double tube type. The internal parts were all made of mild steel, for although it was known that this would be attacked by hydrogen and by sulphur, it was considered that expenditure on more expensive materials was not justified until the design was more developed.

The design incorporated a feature which has been characteristic of Billingham practice, that is, the reaction vessel itself does not have to withstand the mechanical stresses due to pressure and is separated from the pressure resisting walls by a layer of heat-insulating material. The inner vessel therefore withstands the temperature and not the pressure, and the outer wall the pressure and not the temperature. This makes the use of expensive materials for the converter forgings unnecessary.

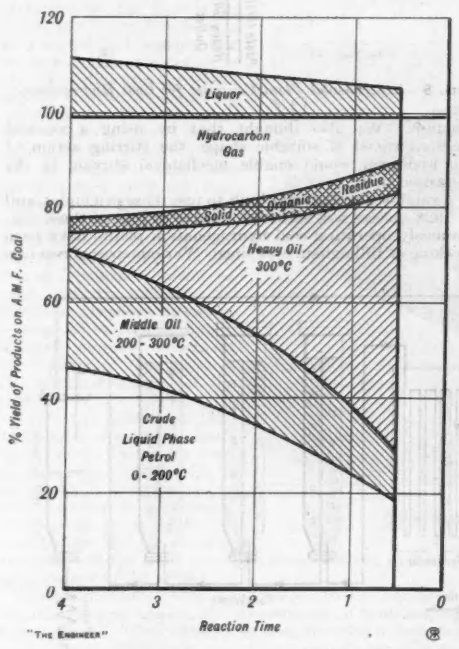


FIG. 8—*Coal Hydrogenation : Effect of Reaction Time on Product Distribution.*

The plant was found to have a capacity of 15 tons per day of coal, making petrol of good quality. The middle oil was stored and the heavier oil disposed of by recirculating it with coal. The treatment of the middle oil—that is, the fraction boiling between about 170 deg. and 300 deg. Cent.—at first presented some difficulties. The oil is so aromatic that it yields a very small quantity of lighter spirit upon cracking. The solution of the problem was found in vapour phase hydrogenation, and a satisfactory plant for this process was built at Billingham, and worked in 1931. The design of this plant was similar to the coal hydrogenation plant.

In 1931 the I.H.P. Agreement made it possible to compare our results with those achieved by the I.G. in Germany and the Standard Oil Company in America.

We found that the I.G. had at first used converters not unlike those employed at Billingham, which had been replaced by simpler and larger units. The converters consist of cylindrical vessels with internal heat insulation. The heat exchangers are of the multitube type, contained in separate forgings. The appropriate number of converter and heat exchanger units are connected in series. The final heating is done by passing the hydrogen and oil simultaneously through tubes in a gas-fired furnace—Fig. 6. This type of plant requires special chrome steels to withstand the action of hydrogen at pressure and at high temperatures.

In order to test the suitability of the I.G.'s type of plant for British coal, a few hundred tons were shipped to Ludwigshafen and a successful experiment was staged there on much the same scale as the original plant at Billingham.

The Billingham pilot hydrogenation plant was closed down at the end of 1931, but research work continued in the laboratories. In 1932 we made further important discoveries concerning the hydrogenation of coal. It was found that the range of coals which could be successfully hydrogenated was much increased by the use of coal cleaning, combined with the use of hydrogen chloride in the reaction vessel.

Coal cleaning is beneficial, not only for the obvious reason that it avoids expensive processing of coal ash, but also because the ash is usually alkaline and has a deleterious effect on catalysis. Hydrogen chloride—added as such or as a compound which forms it under reaction conditions—neutralises the residual ash, and a further quantity has a beneficial effect on the hydrogenation reaction itself. Full benefit of this discovery could not be made until we discovered a method for neutralising the hydrogen chloride in the vapours leaving the converter before cooling. Even before hydrogen chloride was added deliberately, we were troubled by corrosion in the heat exchangers and coolers after the converters, due to the condensation of hydrochloric acid. Further, the tubes were liable to become choked through deposits of ammonium chloride and ammonium carbonate.

In 1933 we found and patented a process for making a stable suspension of alkali in oil, and for freeing the hot vapours at 450 deg. Cent. from acidic constituents by scrubbing them with it. This permitted the use of relatively high concentrations of hydrogen chloride in the reaction space, since the corrosion at reaction temperature is negligible. These two inventions, the use of chlorine and tin compounds as catalysts, and the neutralisation of the vapours with alkaline paste, put the hydrogenation of bituminous coal on an absolutely sound practical basis.

A further change decided upon as a result of our research work was to divide the process into three stages. The primary hydrogenation of coal gives gas, petrol, middle oil, and heavy oil. It is possible to control the reaction conditions so that there is neither a loss nor gain of heavy oil, and the production is exactly enough to make coal into a paste for reintroduction into the converter—Fig. 7. This gives a simple plant arrangement, but has the drawback that coal and heavy oil are being hydrogenated under identical conditions, which cannot be best for both reactions.

We decided therefore to operate with reduced reaction volume so as to give a surplus of heavy oil—Fig. 8. The heavy oil is then treated separately under more suitable conditions than those existing during the hydrogenation of coal, and the overall yield is thus increased—Fig. 9.

This method of operation is only desirable in units of the largest size. In smaller plants the small decrease in yield due to two-stage operation is more than compensated for by lower capital and operation costs due to greater simplicity.

In spite of the progress we have made, work in the laboratories is still continuing and doubtless will do so for many years. Owing to the congestion of the laboratories at Billingham, it was decided last year to erect new buildings which are to be devoted to coal hydrogenation entirely.

On page 568 there is illustrated the plant recently erected at Billingham for the commercial hydrogenation of coal with which the remainder of this article is concerned.

(To be continued.)

CONTRACTS AND ORDERS.

The Editor is always happy to print short announcements of contracts and orders in this column provided they are sent to him in time to have news value and that they are likely to interest readers.

DAVEY, PAXMAN AND CO. (COLCHESTER), Ltd., have received an order for six Paxman-Ricardo high-speed Diesel engines, each of six cylinders, developing 55 b.h.p. at 1000 r.p.m., for installation in locomotives, which F. C. Hibberd and Co., Ltd., of Park Royal, London, N.W.10, are building for the Consolidated Gold Fields for use in West Africa.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

H. HILDITCH, Ltd., of Birmingham, non-ferrous ingot manufacturers and merchants, have opened a branch office at 76, Chancery-lane, London, W.C.2.

CLIFFORD AND SNELL (Eng.), Ltd., have vacated their offices at 16, Queen Anne's-gate, S.W.1, so as to centralise their activities at their new works situated at Sutton, Surrey.

MR. H. KENNETH ROGERS, Tren Crom, Wenallt-road, Rhiwbina, Cardiff, has been appointed representative for M. and C. Switchgear, Ltd., Glasgow, in the South Wales and West of England districts, commencing December 2nd, 1935.

MR. NORMAN A. COLLARD, who resigned his position as assistant general manager of the Brush Electrical Engineering Company, Ltd., Loughborough, in April last, and has since been representing the Aktiebolaget Ljungstroms Angturbin, of Stockholm, on special negotiations in this country, has now joined the staff of John Thompson Water-Tube Boilers, Ltd., Wolverhampton.

THE LIVERPOOL REFRIGERATION COMPANY, Ltd., of Colonial House, Water-street, Liverpool, which has for some time past manufactured Maiuri absorption process refrigeration plants to the orders of Maiuri Refrigeration Patents, Ltd., of Bush House, London, W.C.2, announces that it has entered into an agreement with Maiuri Refrigeration Patents, Ltd., which will enable the Liverpool company to manufacture and sell under licence within the British Empire (excluding Canada) refrigerating plants manufactured under the Maiuri patents.

VICKERS, Ltd., announces the following changes in the constitution of its board of directors and of the boards of its subsidiary companies, Vickers-Armstrongs, Ltd., and English Steel Corporation, Ltd., consequent on the death of Sir Mark Webster Jenkinson, and the acquisition by Vickers, Ltd., of the whole of the share capital of Vickers-Armstrongs, Ltd. The following have been appointed to the board of Vickers, Ltd.:—Major-General Sir John Humphrey Davidson and Mr. F. C. Yapp. As from January 1st, 1936, the board of directors of Vickers-Armstrongs, Ltd., will be constituted as follows:—Commander Sir Charles Craven, chairman and managing director; General Sir J. F. Noel Birch; Sir A. George Hadcock; Mr. F. C. Yapp; Mr. J. Callander, general manager of the Barrow Works and Naval Yard, Newcastle-on-Tyne; and Mr. J. Reid Young, secretary of Vickers, Ltd. As from January 1st, 1936, Commander Sir Charles Craven will be chairman of English Steel Corporation, Ltd., in place of Colonel J. B. Neilson, and will retain his office as managing director. Mr. F. Pickworth will be a director of English Steel Corporation, Ltd., from the same date.

LAUNCHES AND TRIAL TRIPS.

ARGOS, twin-screw motor ship; built by Henry Robb, Ltd., Leith, to the order of the Compagna Argentina de Lanchas; dimensions, 285ft. by 50ft. by 14ft.; to carry cargo on river Plate. Diesel engines of Polar type; launch, September 26th; a speed of 10½ knots was attained on trial trip, November 20th.

CATALOGUES.

THERMOTANK, Ltd., Helen-street, Glasgow, S.W.1.—Latest catalogue on the "Punkah" louvre.

GENERAL ELECTRIC COMPANY, Ltd., Magnet House, Kingsway, W.C.2.—Catalogue Section W2, "Magnet Wiring Systems."

STAVELEY COAL AND IRON COMPANY, Ltd., near Chesterfield.—A book describing the works and products of the company.

STRAIGHT-LITE REFLECTORS, Ltd., 73, Canonbury-road, London, N.1.—List No. 46 of "Straight-Lite" architectural lighting fittings.

MATHER AND PLATT, Ltd., Park Works, Manchester, 10.—A pamphlet No. P821 describing the firm's horizontal split-casing steam turbines.

W. T. HENLEY'S TELEGRAPH WORKS COMPANY, Ltd., Holborn Viaduct, E.C.1.—Sixth edition of the cable jointing and installation equipment catalogue.

G. A. HARVEY AND CO., Ltd., Woolwich-road, London, S.E.7.—List No. 645, of mild steel gilled tubes for refrigeration, heating, and electrical equipment.

HUNT AND MITTON, Ltd., Oozells-street North, Birmingham, 1.—A 314-page sectionalised catalogue of steam valves, boiler mountings, lubricators, and kindred fittings.

B. J. ROUND AND SONS, 8, Northampton-street, Birmingham, 18.—A handbook, "The Electroplating and Metal Finishing Industry and the 'Epalex' System," price 1s. net.

JAMES KEITH AND BLACKMAN COMPANY, Ltd., 27, Farringdon-avenue, London, E.C.4.—Booklet 121 on "K-B" air heaters with steam or hot water as heating medium.

GLENFIELD AND KENNEDY, Ltd., Kilmarnock.—A catalogue dealing with free roller sluice gates and illustrating a number of the more important sluice gate barrages the firm has supplied.

Markets, Notes and News.

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer. A comprehensive list of the prices of materials mentioned below will be found on the next page.

The Continental Steel Situation.

Since the opening of the last quarter of the year the world's trade in iron and steel has developed sufficiently to relieve the Continental steel makers of any anxiety regarding their position until the end of January. It is the first time this year that the works in Belgium and in France have been in this happy position; but the German works have been able steadily to increase their output since early in the spring. With their immediate future provided for the steel makers have been able to proceed with the organisation of their industry under the direction of the European Steel Cartel. For some time they have been preoccupied with the position in the French home market. The comptoirs controlling the domestic trade should have been renewed on June 30th, as the agreement upon which they were founded expired on that date. Difficulties, however, developed between some of the most important French steel companies, and until recently it seemed almost impossible that the temporary prolongation of these organisations could be made permanent. It was finally decided that an agreement would have to be reached by November 23rd. One important firm, possessing works in Germany and France, held out until the last, but at the beginning of this week it was agreed to renew the comptoirs for a period of five years, although apparently certain reservations have been made which will call for consideration of the position in six months. The efforts to form an international thin sheet comptoir have hitherto proved unsuccessful. The British sheet makers are pressing for the formation of this organisation, and at times it has seemed this would be achieved. It is expected that the final decision will have to be made shortly, but the attitude of the Belgian Phœnix works makes this somewhat improbable. At the annual meeting the chairman delivered a rather violent attack upon the British steel makers and was apparently supported by some of the shareholders. The outlook, therefore, is not favourable at the moment, although in business negotiations of this kind events have a way of taking unexpected turns. In Germany some sensation has been occasioned by the introduction of export licences. It is not anticipated that this will greatly affect the volume of German export business, but it puts the control more completely in the hands of the Cartel, as exporters have to state the price at which the steel is sold and its destination. According to reports, the Cartel hopes that other European countries and also Great Britain will adopt a similar system.

Pig Iron.

During the past four months the production of pig iron has not been increased in accordance with the expectations of consumers. On the other hand, the demand has expanded over that period and the stringency which made itself felt in some districts early in the summer has become more noticeable. When the demand first developed, producers naturally wished to dispose of some of their stocks, which amounted to a considerable tonnage; but now these are not more than sufficient to provide a margin of security, and consumers argue that more furnaces should be put into blast. The producers, however, appear to be trying to balance production and consumption and do not seem in any hurry to increase their outputs. On the North-East Coast there are only three furnaces producing Cleveland, and the general view is that these are not able adequately to meet the needs of the market. The local demand appears to be increasing and business with Scottish users is on a good scale. Practically no business has been transacted on export account since not only is there no surplus after the home demand is met, but the prices paid in overseas markets are not sufficiently attractive. In the Midlands a slight check followed the recent advance in prices, but business has again become active and promises to develop as much strength as when the cheaper rates prevailed. Most of the recent new business has been in small tonnages, but in the aggregate these have reached a good total and at the same time specifications against existing contracts are putting pressure on the works. In Lancashire the demand is rather quieter, but the amount of iron passing into consumption is large enough to absorb the local production. The ironfoundries in this district are well employed and provide an outlet for substantial quantities of foundry iron. In Scotland the demand is steady and the consuming industries are taking regular supplies. The important consumers have covered their needs in some cases over the first half of next year, but specifications are reaching the works at a satisfactory rate. Business in hematite has been active and the demand seems to have settled down on steady lines. There is considerable speculation in the market as to whether prices will be advanced, but the general impression is that the pig iron makers will not alter their present quotations until the New Year.

The North-East Coast and Yorkshire.

All the works on the North-East Coast are actively employed and in some departments the difficulty of meeting customers' requirements is becoming accentuated. The recent announcement of the railway companies' programmes has come at a time when the mills were beginning to want fresh business; but the amount of work which they will receive as a result of these orders will provide them with plenty of employment over the early part of next year. The production of semi-finished steel materials is still insufficient to meet consumers' needs, and the works are dropping behind with deliveries. Users find a difficulty in placing orders, since many manufacturers have their whole production sold for as far forward as they care to accept orders. In this district the manufacturers declare that they have not put up their prices and that any business transacted is at the official figures based on £5 10s. for soft untested billets in 500-ton lots, 100 tons of a size. For sheet bars £5 5s. is quoted, although higher prices are being charged by producers in other parts of the country. The position of the constructional engineering departments is satisfactory, although complaints are heard of late delivery of structural steel material against contracts. The pressure upon the makers of joists and sections, however, is sufficient to account for this delay, as the consumers' requirements have been particularly heavy of late. Recently new business has not been quite so active, and this may be due to the attitude of the makers, who in some cases are disinclined to accept business unless it is accompanied by specifications, and for the most part cannot promise the execution of orders before January. There has been a noticeable improvement in the demand for sheets, both on home and export account. The increase in the requirements of overseas markets, however, is no more than is usually experienced at this season of the year. The Yorkshire steel industry is busily employed in practically every department, excepting perhaps malleable iron. In Sheffield record outputs are being made, and, as in other districts, the demand for basic billets is a feature of the market. An improvement in business in acid carbon billets is reported, whilst there is a strong request for wire rods. The finished steel departments are well occupied and some good orders have lately been placed by the motor car manufacturers. After being stationary for some time, business in high-speed steel is improving.

The Midlands and South Wales.

The Midland steel markets have rarely been so busy as during the past week or two. The only cause for complaint seems to be the difficulty of obtaining supplies of raw materials. The manufacturers take the view that a proportion of the buying is of a speculative character and are inclined to scrutinise the orders they receive. Anticipations of a price advance, of course, have had much to do with the desire on the part of users to place forward contracts, but much of the business offering represents buying against orders in hand. In some instances the consuming works complain that their operations are being hampered and their output restricted by the difficulty of getting deliveries against contracts. The constructional engineering firms in the Midlands are all reported to be working at capacity, and their requirements provide the makers of joists and sections with as much work as they can execute within reasonable time. New factories are continually being erected in the Midlands and the material required for these and for aerodromes and public works in course of execution amounts to a very heavy tonnage. It is in the semi-finished steel department, however, that the difficulty of securing supplies is most noticeable. The additional supplies which the British Iron and Steel Federation has ordered from the Continent have not yet been distributed, and in some cases works' operations are restricted by a lack of billets. There has been an increase in the demand for sheet bars also, but the scarcity of this material is not so acute. The re-rolling works in the Midlands are sharing in the rush of business almost to the same extent as the steel works, but as they have to purchase their supplies of raw material they are not in such a happy position as the latter. The quotations for steel bars, which are in good demand, are firm at £8 for reinforced concrete quality, d/d Midlands, either from associated or unassociated works. In the case of better quality bars the associated makers ask £8 12s., less rebates of from 2s. 6d. to 5s., whilst unassociated works quote £8 5s. to £8 7s. 6d. Business in the South Wales market is steadily expanding and, as in other districts, consumers are showing anxiety to cover their steel requirements far forward. In spite of the fact that the South Wales tin-plate industry is working at not more than 55 per cent. of capacity and is restricted by the International Tin-plate Association arrangements from accepting business before March, except in special circumstances, there is a good demand for semis. This arises from an increased request for steel materials from the structural engineers and shipbuilders.

Current Business.

The Portsmouth Corporation has placed an order for seventy-six all-metal bodies for double-decked trollybuses with Cravens Railway Carriage and Wagon Company, Ltd., of Darnall, Sheffield. The Mersey Cable Works, Ltd., have placed contracts for the erection of two new buildings at their Bootle factory. James Howorth and Co., Ltd., manufacturers of ventilating equipment, Farnworth, near Bolton, have obtained an order for five plants for mills at Shanghai, in addition to ten plants already supplied by the company for these mills. Ruston and Hornsby, Ltd., and R. A. Lister and Co., Ltd., announce that the rationalisation scheme between the two companies reached in 1930 will be terminated by mutual consent on March 31st, 1936. The reason is the gradual change in factors affecting the two businesses. The Corby Water Board has approached the Leicester Water Committee with regard to a project for the supply of water to the Corby steel works of Stewarts and Lloyds, Ltd., and for the building up of a new water reserve for Leicester. The proposal is to construct a dam and reservoir in the Eye Valley. The Glasgow Electrical Committee has recommended the acceptance of tenders for the extension of the Dalmarnock power station, submitted by C. A. Parsons and Co., Ltd., Newcastle, amounting to £353,770, and by Babcock and Wilcox, Ltd., of Renfrew, of £491,045. David Brown and Sons (Huddersfield), Ltd., announce that it is hoped to instal fresh plant on the site of the Yorkshire Iron and Steel Works at Penistone, which they purchased early this year, and to commence operations at the foundry in January. Colvilles, Ltd., announce extensions to their Glengarnock Steel Works, which will include the laying down of a new blooming mill. The loading and cooling banks will be extended, and two new open-hearth melting furnaces will be added to the existing four furnaces. It is estimated that the cost of the scheme will amount to £250,000, and the new plant when completed will be capable of producing 2,500 tons of semis per week. The adjacent plant of the Colville Constructional Co. is also to be extended, and electro-welding equipment is to be installed. The Department of Overseas Trade announces that the following contracts are open for tender:—Wellington, New Zealand, Posts and Telegraphs Department: 3000 metal-cased condensers (Wellington, January 21st); 32,000 galvanised steel coach screws, 2½in. by ⅜in. (Wellington, January 23rd); Auckland Electric Power Board: 6600-volt, metal-clad, compound-filled switchgear (fifteen sets), and one self-cooled, oil-immersed, 6000 kVA transformer (Auckland, January 20th). Argentine State Railways: Supply of spades, shovels, picks, and saws, and wooden handles for tools (Buenos Aires, December 26th). Egyptian Ministry of Public Works: One light Diesel locotractor, about 25 b.h.p., and ten wagons, each of 1 cubic metre capacity, with accessories and spares (Cairo, December 24th). South African Railways and Harbours: Steelwork, galvanised corrugated sheeting, glass and roller doors, &c., for the brass and ironfoundry at Salt River (Johannesburg, January 6th); material for the complete covering of the main engine-room and platform roofs of the precooling store, Port Elizabeth Harbour, the material to be preferably protected metal and to include all fittings (Johannesburg, January 13th).

Copper and Tin.

After a slight improvement in the general demand for electrolytic copper, the market has again become quieter. Consumers appear to have sufficient stocks in hand to enable them to hold off the market for a time, but the general impression is that in no country are users well covered. Political conditions in Europe, however, are against free buying, even if it were possible in the face of import quotas, exchange difficulties, and other restrictions. The possibility that the sale of copper to Italy will be added to the list of prohibited dealings has been followed by more active Italian buying, although the likelihood of this course being adopted is more remote now than at the beginning of the week. In America the demand has been quieter than for some weeks past, but the producers have shown no desire to press sales, so that the American domestic quotation of 9·25c. d/d Connecticut Valley continues to rule. The statistical position of the metal is still improving and at the end of October the world's stocks were estimated at 496,500 tons, compared with 531,600 tons at the end of the previous month. The stocks in the United States were 226,600 tons, compared with 241,300 tons on September 30th. The world's production showed an increase to 129,500 tons, against 113,600 tons in September. Production in the United States during October was 46,200 tons. On the London standard market prices have shown a slight tendency to advance. It seems fairly evident that there is no large bull account open, since whilst the stocks total over 90,000 tons the contango rate is only about 2⅛ per cent. Normally, with so much copper in stock, the rate would be nearer 5 per cent. . . . Easier conditions have ruled in the tin market of late, probably as a result of the expected arrival of supplies of Banca tin. The backwardation also has declined to about £10. Interest in this market, however, is rather lethargic and the tendency seems to be to wait until the position which is likely to rule in December can be better gauged. The demand from the Continent has been poor, but the position in Italy is closely watched, since it is believed that large stocks have been accumulated in that country. If it happened that hostilities in Abyssinia suddenly ceased and the international situation became easier, the Italians might be in the position of having to realise superfluous tin and this would probably disorganise the market.

Lead and Spelter.

Firmer conditions have again developed in the lead market and a further rise in prices seems to be anticipated. Deliveries this month will have to be taken from warehouse, as no further imports of lead are expected. This, however, was foreseen earlier in the month, as it has been obvious for some time that the quantities of Empire lead arriving in this country for some time would be sufficient only to meet deliveries against contracts. The consumptive demand shows no signs of weakening and a continuation of the tight position which has existed for so many weeks seems to be inevitable. Hopes that arrivals of Mexican lead would relieve the position have not been fulfilled and apparently fresh labour troubles in that country are operating against normal production. The producing interests have sold on the Metal Exchange with some freedom and this, of course, has assisted in keeping prices steady. . . . No fresh feature of importance has developed in the spelter market, but prices have been remarkably steady, the fluctuations being almost insignificant. The demand from consumers has been moderate, but there has been some increase in the requirements of the galvanisers, which is looked upon as a hopeful sign. The announcement that negotiations had been commenced for the revival of the International Zinc Cartel has aroused considerable interest, but it is not anticipated that anything will materialise for some time. The adverse influences which caused the break up of the Cartel still operate and there does not seem to be any strong desire on the part of some Continental interests to renew the organisation. Lately there have been some arrivals of Belgian spelter and further shipments are expected to reach this country at the end of the month. In America, although the position does not influence the London market, conditions have improved and this month the industrial demand has appreciably expanded. On the London market the contango, as frequently happens towards the end of the month, shows a tendency to disappear, but will probably become normal at about 6s. 3d. early in December.

Current Prices for Metals and Fuels.

Makers' official home trade prices per ton, delivered buyers' stations. Sections, joists and plates are subject to a rebate to home users purchasing only from associated British Steelmakers: joists, 22s. 6d.; plates and sections, 15s. Export orders of 250 tons and over may be subject to special quotations.

PIG IRON.

	Home.	Export.
	(*D/d Teesside Area*)	
N.E. Coast—	£ s. d.	£ s. d
Hematite Mixed Nos.	3 10 6	3 2 0
No. 1	3 11 0	3 3 6
Cleveland—	(*D/d Teesside Area*)	
No. 1	3 12 6	3 4 0
No. 3 G.M.B.	3 10 0	3 1 6
No. 4 Forge	3 9 0	3 0 6
Basic (*Less 5/– rebate*)	3 10 0	—
Midlands—		
Staffs.—	(*Delivered to Black Country Station*)	
North Staffs. Foundry	3 15 0	—
„ „ Forge	3 10 0	—
Basic (*Less 5/– rebate*)	3 15 0	—
Northampton—		
Foundry No. 3	3 12 6	—
Forge	3 7 6	—
Derbyshire—		
No. 3 Foundry	3 15 0	—
Forge	3 10 0	—
Scotland—		
Hematite, f.o.t. furnaces	3 13 6	—
No. 1 Foundry, ditto	3 16 6	—
No. 3 Foundry, ditto	3 14 0	—
Basic, d/d (*Less 5/–rebate*)	3 10 0	—
N.W. Coast—		
Hematite Mixed Nos.	3 14 0 d/d Glasgow 3 18 6 „ Sheffield 4 4 6 „ Birmingham	

MANUFACTURED IRON.

	Home.	Export.
Lancs.—	£ s. d.	£ s. d.
Crown Bars	9 12 6	—
Best Bars	10 2 6	—
S. Yorks.—		
Crown Bars	9 12 6	—
Best Bars	10 2 6	—
Midlands—		
Crown Bars	9 15 0	—
Marked Bars (Staffs.)	12 0 0	—
No. 3 quality	7 17 6	—
No. 4 „	8 10 0	—
Scotland—		
Crown Bars	9 12 6	9 5 0
Best	10 2 6	9 15 0
N.E. Coast—		
Common Bars	9 12 6	8 15 0
Best Bars	10 2 6	9 15 0
Double Best Bars	10 12 6	10 0 0

STEEL.

	Home.	Export.
London and the South—	£ s. d.	£ s. d.
Angles	8 10 0	7 10 0
Tees	9 10 0	8 10 0
Joists	8 17 6	7 10 0
Channels	8 15 6	7 15 0
Rounds, 3in. and up	9 10 0	8 10 0
„ under 3in.	8 14 6	7 0 0
Flats, 5in. and under	8 14 6	7 0 0
Plates, ¼in. (basis)	9 0 0	7 15 0
„ 5/16in.	9 5 0	8 0 0
„ ⅜in.	9 10 0	8 5 0
„ 7/16in.	9 15 0	8 10 0
„ ½in.	9 10 0	8 5 0
North-East Coast—	£ s. d.	£ s. d.
Angles	8 7 6	7 10 0
Tees	9 7 6	8 10 0
Joists	8 15 0	7 10 0
Channels	8 12 6	7 15 0
Rounds, 3in. and up	9 7 6	8 10 0
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	7 17 6
Plates, ¼in.	8 13 0	7 15 0
„ 5/16in.	9 0 0	8 0 0
„ ⅜in.	9 5 0	8 5 0
„ 7/16in.	9 10 0	8 10 0
„ ½in.	9 5 0	8 5 0
Boiler Plates, ¼in.	9 5 0	—
Midlands, and Leeds and District—	£ s. d.	£ s. d.
Angles	8 7 6	7 10 0
Tees	9 7 6	8 10 0
Joists	8 15 0	7 10 0
Channels	8 12 6	7 15 0
Rounds, 3in. and up	9 7 6	8 10 0
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¼in. (basis)	8 17 6	7 15 0
„ 5/16in.	9 2 6	8 0 0
„ ⅜in.	9 7 6	8 5 0
„ 7/16in.	9 12 6	8 10 0
„ ½in.	9 5 0	8 5 0
Boiler Plates, ¼in.	9 7 6	7 15 0

STEEL (*continued*).

	Home.	Export.
Glasgow and District—	£ s. d.	£ s. d.
Angles	8 7 6	7 10 0
Tees	9 7 6	8 10 0
Joists	8 15 0	7 10 0
Channels	8 12 6	7 15 0
Rounds, 3in. and up	9 7 6	8 10 0
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¼in. (basis)	8 15 0	7 15 0
„ 5/16in.	9 0 0	8 0 0
„ ⅜in.	9 5 0	8 5 0
„ 7/16in.	9 10 0	8 10 0
„ ½in.	9 5 0	8 5 0
Boiler plates	9 5 0	—
South Wales Area—	£ s. d.	£ s. d.
Angles	8 7 6	7 10 0
Tees	9 7 6	8 10 0
Joists	8 15 0	7 10 0
Channels	8 12 6	7 15 0
Rounds, 3in. and up	9 7 6	8 10 0
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¼in. (basis)	8 17 6	7 15 0
„ 5/16in.	9 2 6	8 0 0
„ ⅜in.	9 7 6	8 5 0
„ 7/16in.	9 12 6	8 10 0
„ ½in.	9 10 0	8 5 0

Ireland—	Belfast.	Rest of Ireland.
	£ s. d.	£ s. d.
Angles	8 12 6	8 15 0
Tees	9 12 6	9 15 0
Joists	9 0 0	9 2 6
Channels	8 17 6	9 0 0
Rounds, 3in. and up	9 12 6	9 15 0
„ under 3in.	9 2 0	9 4 6
Plates, ¼in. (basis)	9 0 0	9 2 6
„ 5/16in.	9 5 0	9 7 6
„ ⅜in.	9 10 0	9 12 6
„ 7/16in.	9 15 0	9 17 6
„ ½in.	9 12 6	9 15 0

OTHER STEEL MATERIALS.

Sheets.	Home. £ s. d.	Export. £ s. d.
10-G. to 13-G., f.o.r.	9 15 0	9 0 0
14-G. to 20-G., d/d	11 0 0	9 5 0
21-G. to 24-G., d/d	11 5 0	9 10 0
25-G. to 27-G., d/d	11 17 6	10 2 6

The above home trade prices are for 4-ton lots and over; 2-ton to 4-ton lots 10s. per ton extra; and under 2-ton lots, 30s. per ton extra.

Galvanised Corrugated Sheets, Basis 24-G.

Home.	£ s. d.
4-ton lots and up	13 5 0
2-ton to 4-ton lots	13 12 6
Under 2 tons	15 5 0

Export: £12 15s. 0d., c.i.f. India.
„ £11 10s. 0d., f.o.b. other markets.
„ Scandinavian Markets free.

Tin-plates.
20 by 14 basis, f.o.b. Bristol Channel Ports, 18s. 9d.
Tin-plate Bars, d/d South Wales Works, £5 10s. 0d.

Billets.	£ s. d.
Basic (0·33% to 0·41% C.)	6 12 6
„ Medium (0·42% to 0·60% C.)	7 2 6
„ Hard (0·61% to 0·85% C.)	7 12 6
„ „ (0·86% to 0·99% C.)	8 2 6
„ „ (1% C. and up)	8 12 6
Soft (up to 0·25% C.), 500 tons and up	5 10 0
100 to 250 tons	5 17 6
Rails, Heavy, 500-ton lots, f.o.t.	8 10 0
„ Light, f.o.t.	7 10 0

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	3/3 per lb.	
Ferro Tungsten	3/– per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£21 15 0	7/–
„ „ 6 p.c. to 8 p.c.	£21 0 0	7/–
„ „ 8 p.c. to 10 p.c.	£21 0 0	7/–
„ „ Specially Refined		
„ „ Max. 2 p.c. carbon	£33 10 0	11/–
„ „ „ 1 p.c. carbon	£36 5 0	11/–
„ „ „ 0·50 p.c. carbon	£37 5 0	12/–
„ „ „ carbon free	9½ per lb.	
Metallic Chromium	2/5 per lb.	
Ferro Manganese (loose), 76 p.c.	£10 15 0 home	
„ Silicon, 45 p.c. to 50 p.c.	£12 15 0 scale 5/– p.u.	
„ „ 75 p.c.	£17 17 6 scale 6/– p.u.	
„ Vanadium	12/8 per lb.	
„ Molybdenum	4/6 per lb.	
„ Titanium (carbon free)	9d. per lb.	
Nickel (per ton)	£200 to £205	
Cobalt	5/6 per lb.	

NON-FERROUS METALS.

Official Prices, November 27th.

Copper—		
Cash	£35 2 6 to £35 3 9	
Three months	£35 10 0 to £35 11 3	
Electrolytic	£39 0 0 to £39 10 0	
Best Selected Ingots, d/d Birmingham	£39 10 0	
Sheets, Hot Rolled	£66 0 0	
	Home.	Export.
Tubes, Solid Drawn (basis)	10¼d.	10¼d.
„ Brazed (basis)	10¼d.	10¼d.
Brass—		
Ingots, 70/30, d/d Birmingham	£32 0 0 to £33 0 0	
	Home.	Export.
Tubes, Solid Drawn, 2/1 Alloy	9¾d.	9¾d.
„ Brazed	11¼d.	11¼d.
Tin—		
Cash	£221 10 0 to £221 15 0	
Three months	£212 0 0 to £212 5 0	
Lead: Cash and forward	£18 1 3	
Spelter:	£16 2 6 to £16 3 9	
Aluminium Ingots (British)	£100	

FUELS.

SCOTLAND.

Lanarkshire—	Export.
(f.o.b. Grangemouth)—Navigation Unscreened	14/– to 14/6
Hamilton Ell	16/6 to 17/–
Navigation Splints	18/– to 18/6
Ayrshire—	
(f.o.b. Ports)—Steam	14/– to 14/6
Fifeshire—	
(f.o.b. Methil or Burntisland)—	
Prime Steam	15/6
Unscreened Navigation	14/– to 14/6
Lothians—	
(f.o.b. Leith)—Hartley Prime	15/6
Secondary Steam	15/–

ENGLAND.

Yorkshire, Manchester—	
B.S.Y. Hard Steams	18/6 to 21/6
Furnace Coke	14/6 to 17/6
Northumberland, Newcastle—	
Blyth Best	15/– to 15/6
„ Second	14/– to 14/6
„ Best Small	10/6 to 11/–
Unscreened	12/6 to 13/6
Durham—	
Best Gas	14/8
Foundry Coke	19/– to 20/–

Sheffield—	Inland.
Best Hand-picked Branch	24/– to 26/–
South Yorkshire Best	21/– to 23/–
South Yorkshire Seconds	18/– to 19/6
Rough Slacks	9/– to 10/–
Nutty Slacks	8/– to 9/6

SOUTH WALES.

Cardiff—	
Steam Coals:	
Best Admiralty Large	19/6
Best Seconds	19/– to 19/4½
Best Dry Large	18/9 to 19/3
Ordinaries	18/3 to 18/6
Bunker Smalls	12/6 to 13/6
Cargo Smalls	11/6 to 12/6
Dry Nuts	22/– to 27/6
Foundry Coke	27/– to 40/–
Furnace Coke	19/– to 22/6
Patent Fuel	21/–
Swansea—	
Anthracite Coals:	
Best Large	36/– to 40/–
Machine-made Cobbles	41/– to 48/6
Nuts	40/– to 48/6
Beans	25/– to 30/–
Peas	19/– to 23/–
Rubbly Culm	11/– to 11/6
Steam Coals:	
Large Ordinary	18/– to 20/6

FUEL OIL.

Inland consumption; contracts in bulk.
Exclusive of Government tax of 1d. per gallon.

Ex Ocean Installation.	Per Gallon.
Furnace Oil (0·950 gravity)	3½d.
Diesel Oil	4d.

French Engineering Notes.

(From our own Correspondent in Paris.)

Foreign Trade Exchanges.

THE only matters that interest the engineering and other industries at the moment are the stabilisation of currencies and the carrying out of commercial treaties that will give renewed vitality to home and foreign business. There is no other opening for manufacturers who find orders dwindling on the home market and prospects becoming less favourable on account of the monetary tension and unsatisfactory trade returns. During the first ten months of the year there was a further decline in the value of imports and exports, and an increase in the export tonnage is not an encouraging indication when it is obviously the result of artificial stimulus and the selling of iron and steel and other "material necessary for industry" at unprofitable prices. The tonnage of exports increased by 4 per cent. and the value declined by 13 per cent. Manufactured goods fell both in tonnage and value. During the past week there have been meetings of the Council of the International Chamber of Commerce and of economic associations at which experts have explained the French view of what should be done to remedy the situation. The Minister of Commerce, Monsieur Georges Bonnet, recapitulated the proposals he made at Geneva to negotiate commercial treaties on as liberal a scale as possible with a group of countries that would undertake to stabilise their currencies over a definite period, the idea being that other countries would subsequently join the group until the world is drawn into a general organisation of trade development. It is a repetition of the scheme that was tried unsuccessfully within the group of gold countries.

Shipbuilding.

A reorganisation of the shipbuilding industry is not so easy as it seemed when the Government decreed that small shipyards must be closed and others amalgamated and specialised, with a view to reducing costs and enabling builders to compete for business under conditions similar to those in foreign yards. The Government's initiative completely failed. It is now argued that shipbuilders labour under disabilities that are beyond the control of the industry and cannot be remedied by any such organisation. The cost of building a ship in a French yard is from 50 to 60 per cent. more than in a British yard. Wages have advanced with high living costs, and builders are precluded from obtaining any alleviation therefrom for competitive business when the scale of wages is specified in Government contracts. Again, the yards suffer inconvenience through being a long way from their sources of supply, with the result that the cost of material is burdened by excessive transport charges. These and other drawbacks are emphasised in order to show that the problem is really one for the State to solve. If there are too many yards the responsibility for that state of things devolves, it is claimed, on the Government, which encouraged the laying out of yards during and after the war. It is further urged that the fifteen or twenty yards would find employment, and be able to reduce prices, if shipowners could renew their fleets and place orders for ships of few types, instead of requiring that every ship should be of a special type, as is the case at present. The builder places the burden of reform upon the shipowner, but the owner declares that, having no money and little freights, he can do nothing without aid from the State, so that finally the State is expected to take the burden upon itself.

A New Construction Dock.

As the length of ships increases, so it has been found necessary to create docks for their construction, and the one to be laid out by the Ateliers et Chantiers de la Loire at the Saint-Nazaire yard possesses particular interest, in that it combines a dry construction dock with a basin into which the hull can be floated for completion. The dock will be constructed parallel with the mouth of the Loire, with a short channel to permit of the completed ship being floated into the river. The walls of the dock will be 32ft. high, and the floor will be at two levels, the lower one with a sluice gate into the channel occupying about a third of the width, while a platform on the higher level for travelling cranes separates it from the dry basin. On the completion of the hull, the dock will be filled to allow of the hull being floated across, underneath the platform, to the other side, and a lowering of the water level will leave the hull afloat in the deep basin, where it will be completely fitted out. The dock is designed for the construction of ships, 300 m. long, and is primarily intended for building 35,000-ton battleships.

Coal Imports.

As this country must import one-third of its total normal requirements in coal, any restriction of imports necessarily affects the interests of the large number of firms engaged in the trade, as well as those of shipping ports, and the railway companies. The handling of 25 million tons of foreign coal in normal years is a factor in national activity and economy that cannot be ignored unless its sacrifice is offset by an equivalent gain in the development of the home colliery industry. There is nothing to show that the gain has justified an excessive restriction of coal imports, particularly in view of the necessity of industrial consumers obtaining coal of the most suitable quality at reasonably low prices. That serious complications arise out of the existing coal policy is clear from the growing agitation against the restrictions imposed on foreign coal. The Central Association of Coal Importers has now appealed for the suppression of the 10 per cent. reduction of quota which came into operation on September 1st last. This claim is strongly supported by the Havre Chamber of Commerce, which points to the probability of the country finding itself short of coal. The Government can hardly do more at present than promise to consider the problem in all its aspects, for it is under obligations to the home colliery industry that can only be relaxed when it is proved to be desirable in the general interest.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., 1s. each.

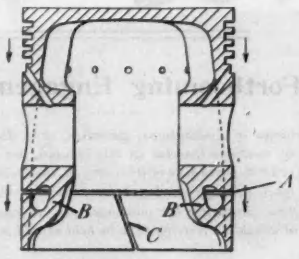
The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

INTERNAL COMBUSTION ENGINES.

436,365. April 9th, 1934.—PISTONS, The Automotive Engineering Company, Ltd., The Green, Twickenham, Middlesex, and R. J. Baker.

This piston is made of aluminium alloy and is specially devised to prevent "slap" when it is running cold, and consequently has not expanded to fit the bore of the cylinder. The

N°436,365



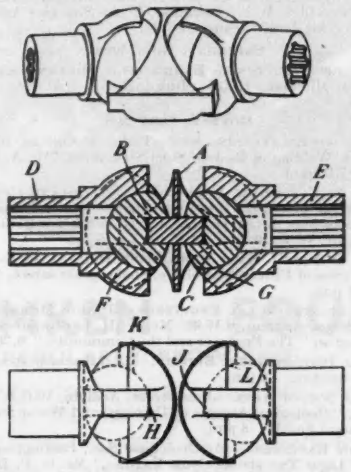
skirt is consequently separated from the body by the slot A, and is carried by the lugs B B. It is also split at C. The skirt can then be made a good fit in the bore when cold, and its resilience will accommodate expansion and contraction. It is also claimed to act as an oil scraper ring.—*October 9th*, 1935.

TRANSMISSION OF POWER.

436,123. February 19th, 1935.—DOUBLE UNIVERSAL JOINTS, O.F.I.C.S.A., 97, Boulevard Gouvion St. Cyr, Paris, France.

As shown in the drawings, there is provided on each side of a central member A a bi-convex or ovoid member B C and a shaft D E. Each shaft is terminated by a fork F G respectively. The shafts are provided internally with splines, which enable them to move longitudinally relatively to shafts provided with corresponding splines, or are directly connected to the driving motor and to the wheels. The forks F and G engage with grooves

N°436,123



H and J provided in the members B and C. Complementary races for balls may be provided in the forks and in the grooves. The members B and C are of an ovoid or bi-convex shape for the purpose of enabling the joint to be made as compact as possible. The centres of curvature about which the opposite faces of each member are described are respectively located on opposite sides of the geometrical centre of the member. The members B C are each provided with a groove K and L respectively, which are at right angles to the groove H and J. The grooves have the same centres of curvature as has the convex surface in which they are formed.—*October 4th*, 1935.

MEASURING AND TESTING INSTRUMENTS.

436,565. January 26th, 1935.—TESTING THE HARDNESS OF MATERIALS, F. H. Willey, 1342, West Vernor-highway, Detroit, Michigan, U.S.A.

The inventor advocates the use of a diamond penetrator for testing the hardness of metals formed as a pyramid with an angle of about 121 deg. and a flattened apex. This, he says, prevents any tendency of the holder to drift from its longitudinal axis in the event of the penetrator encountering a hard or soft spot in the metal during the testing operation. It will be further noted that the meeting edges of the flat sides will act as cutters during the impression operation and will permit the penetrator more easily to enter the surface of the metal being tested, thereby prolonging the life of the penetrator. From the use of this penetrator in service, the conclusion is reached that the ease with which penetration can be effected while the tendency of the penetrator to "drift" under load is materially decreased, is due to the fact that, in forming the penetrator with the series of flat faces in pyramidal form, the ridges between the faces which also extend from the point upwardly at an angle one to the other act as cutters as previously stated, and as the penetration proceeds continuously extend outwardly into the metal. Thus the metal displaced or extruded by each face is segregated from that extruded by the contiguous faces whereby the pressures about the tool are equalised. With the "cone" type of penetrator previously in use, one side of the cone in penetrating metal of somewhat greater hardness than the opposite side of the cone tends to drift and thus gives an inaccurate depth reading, as part of the force of the load is diverted to side pressure. By separating the surface being entered by means of the ridges between flat surfaces, which ridges extend at an equal angle one to another, the metal will more easily extrude due to each separate

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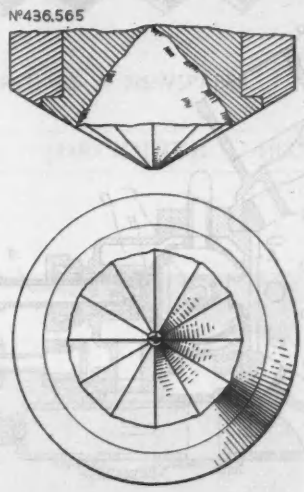

space between the ridges being separated from that extruded by the adjacent faces.—*October 14th*, 1935.

435,676. January 15th, 1935.—SURVEYING WELLS, Naamlooze Vennootschap de Bataafsche Petroleum Maatschappij, 30, Carel van Bylandtlaan, The Hague, Holland.

The inventors use the specific heat and heat conductivity of the rocks through which a bore-hole passes to map out the strata passed through. For this purpose the circulation of the mud slush used in drilling is temporarily suspended, and the temperature of the slush is deliberately made different to that of the rock surrounding the bore-hole, preferably in a minus

N°435,676

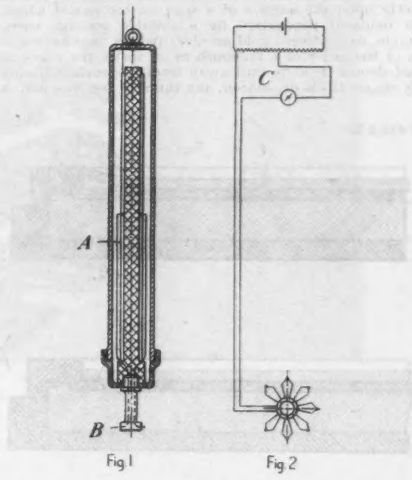

Fig. 1 Fig. 2

direction. The instrument illustrated is then lowered into the hole and the rate of change of temperature it records gives some indication of the strata passed through. The instrument comprises a casing within which there is arranged a series of copper bars A. These bars are connected with thermo-couple wires, as shown in Fig. 2, with the opposite couples in the head B, where they are exposed to the liquid temperature. The thermo-couples are connected in series and the temperature changes are observed by means of the potentiometer shown at C in Fig. 2.—*September 25th*, 1935.

PUMPING AND BLOWING MACHINERY.

436,034. August 29th, 1934.—CENTRIFUGAL PUMPS, *Worthington-Simpson, Ltd., Lowfield Works, Newark-on-Trent.*

This is a multi-stage centrifugal pump for high pressures, with the impellers arranged back to back in pairs, so that the axial thrust is balanced as nearly as is possible. Should an odd number of impellers be required a balancing piston is included. The

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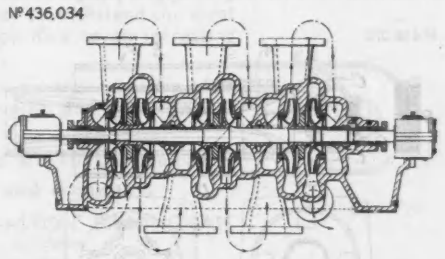


chief claim in the specification seems to be for the splitting of the casing in a plane parallel with the axis of the spindle, each part of which is integral and includes pairs of chambers for the several pairs of impellers, the pairs of chambers being separated by a common wall, and the provision of conversion conduits extending outside the casing to afford communication between successive stages.—*October 3rd*, 1935.

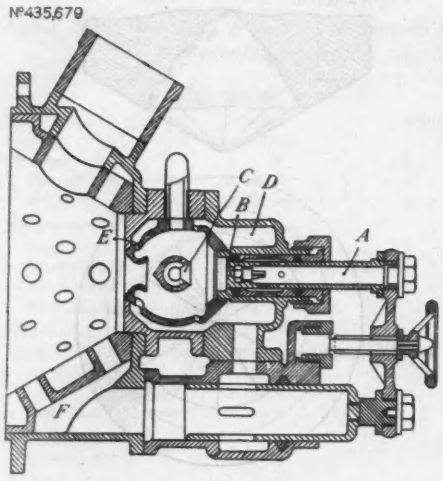
FURNACES.

435,679. January 29th, 1935.—LIQUID FUEL BURNERS, Société pour le Perfectionnement de la Chaufferie, 48, Rue La Boetie, Paris, France.

The aim in this oil burner is to obtain good combustion over a wide range of consumption. The oil is supplied at A and is atomised by the nozzle B. In front of this nozzle there is an

opening C, which leads back to the fuel supply. The nozzle can be moved backwards and forwards, and, according to its proximity to the opening C, more or less of the oil spray is diverted from the furnace. Air for combustion is supplied from the chamber D through the tangential holes E and any heavy

No435,679



particles of oil from the jet are projected against the walls of the globular chamber to drain back to the fuel supply. Secondary air is supplied to the burner through the passages F.—*September 25th*, 1935.

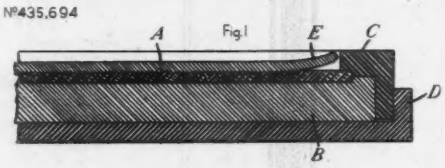
MISCELLANEOUS.

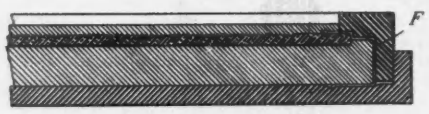
435,694. June 18th, 1935.—The Electrolytic Deposition of a Metal upon a Metallised Non-conducting Surface, Electrical Research Products, Inc., 195, Broadway, New York, U.S.A.

This invention is primarily concerned with the electro-deposition method of repeating gramophone records, but might be applicable in other directions. It has, the inventors say, been observed that when it is attempted to electro-deposit nickel directly upon the surface of a wax master record which has been rendered conductive by a suitable coating, such, for example, as sputtered gold or silver (which may have a thickness of the order of a millionth of an inch), the edges of the nickel deposit tend to curl away from the surface during the early stages of the deposition, and this curl becomes permanent

No435,694

Fig.1



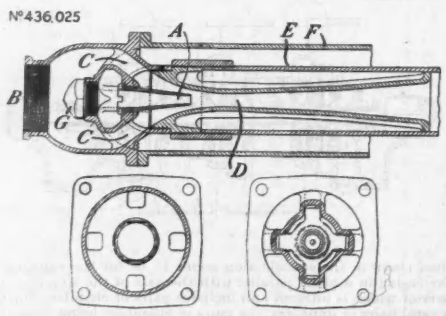


as the thickness of the coating increases. If the curl extends across a portion of the recorded matter the entire master is rendered worthless. The direct cause of the curl appears to be a tension in the thin deposit of nickel which pulls it away from the wax surface, and with it the sputtered metal or other conductive coating. The proximate cause of the curl may be various impurities which appear in the average commercial nickel-plating bath and the removal of which requires unusual care and attention. In Fig. 1 there is shown the wax matrix A, backed with metal B, and encased by rubber clamps C and D. The nickel deposit is shown curling up at the edge at E. The cure is to arrange clips of phosphor bronze wire F round the edges. These clips become embedded in the deposited metal, but are subsequently cut away with the surplus edge.—*September 25th*, 1935.

436,025. June 27th, 1934.—Hydraulic Ejectors, Gresham and Craven, Ltd., Ordsall-lane, Salford, J. Neville, and C. Arnold.

This ejector is of the type adopting the principle of the entraining action of a high-pressure jet of water. This jet is delivered from the nozzle A. The water to be lifted enters by the connection B, and, flowing through the passages C, enters

No436,025



the ejector tube D, and is sent away by the pipe E. The pressure water for working the ejector is supplied through the annular space between this pipe and the outer pipe F, and is conducted to the nozzle A through passages alternating with those marked C. Emphatic reference is made in the specification to the shape, illustrated, of the plug G, which is necessary to enable the ejector to be machined.—*October 3rd*, 1935.

436,103. May 26th, 1934.—Transmission Belting, Fleming, Birkby and Goodall, Ltd., West Grove Mill, Halifax, Yorks., and J. Rigby, 67, Pharos-street, Fleetwood, Lancs.

This invention relates to conveyor belting, transmission belting, or the like, more particularly of the kind composed of vulcanised rubber provided with a woven textile core and suitable for heavy duties and varying atmospheric conditions. In practice, it has been found that belting of this description, although much cheaper to make and possessing greater tensile strength then leather belting, is apt to split longitudinally into two or more parts. The object of the invention is an improved construction of such belting, by introducing in the woven textile element by way of reinforcement a weft composed of fibres of greater tensile strength than the fibres of which the warp is made. By these means any tendency of the belt to split is immediately arrested and deflected by the stronger weft threads towards the selvedge, when it is readily noticed, and may be easily mended before further damage is done. The core consequently is made as a woven fabric composed of preferably vegetable fibres of which the warp threads may be of cotton fibres, the weft threads being composed of fibres possessing a greater tensile strength than the warp threads, such as threads composed of flax, hemp, jute, ramie, or like fibres or a proportion or a combination thereof. The fabric in the course of being manufactured into belting is passed between rollers, during which it is impregnated with a composition in solution, such as rubber, gutta-percha, or the like. The fabric so treated is then folded longitudinally or built up into the required number of folds or plies according to the thickness of the belt required, and is subsequently encased within an outer cover of rubber, stretched and vulcanised in the known manner.—*October 4th*, 1935.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

Inst. of Electrical Engineers: S. Midland Centre.—Grand Hotel, Birmingham. Annual dinner. 6.30 for 7 p.m.

Inst. of Marine Engineers.—Grosvenor House, Park-lane, W.1. Annual conversazione. 7.30 p.m.

Inst. of Mechanical Engineers.—Storey's-gate, St. James's Park, S.W.1. Thomas Hawksley Lecture. "Muscles and Nerves: The Maintenance of Posture, the Development of Power, and the Transmission of Messages in the Body," Professor A. V. Hill. 6 p.m.

Inst. of Production Engineers.—Holborn Restaurant, London, W.C.1. Annual dinner.

Junior Inst. of Engineers.—39, Victoria-street, S.W.1. Informal meeting. Lecture, "Application of Statistics to Industrial Problems," Mr. B. P. Dudding. 7.30 p.m.

Northampton Polytechnic Institute.—St. John-street, E.C.1. Conversazione. 7–11 p.m.

North-East Coast Inst. of Engineers.—Bolbec Hall, Newcastle-upon-Tyne. "The Theory of the Bulbous Bow and its Practical Application," Mr. W. C. S. Wigley. 6 p.m.

Royal Institution of Great Britain.—21, Albemarle-street, Piccadilly, W.1. Discourse, "The Size and Age of the Universe," Sir James Jeans. 9 p.m.

SATURDAY, NOV. 30TH.

Inst. of Structural Engineers: Midland Counties Branch.—Midland Hotel, Birmingham. Annual dinner. 6.45 p.m.

MONDAY, DEC. 2ND.

Bradford Engineering Soc.—Technical College, Bradford. "Electric Welding in Modern Steel Structures," Mr. A. Ramsay Moon. 7.30 p.m.

Inst. of Electrical Engineers: S. Midland Centre.—James Watt Memorial Inst., Gt. Charles-street, Birmingham. "Considerations in the Design of a High-fidelity Radiogramophone," Mr. W. J. Brown. 6.15 for 7 p.m.

Inst. of Fuel: East Midland Section.—Visit to Mining Laboratories of University College, Shakespeare-street, Nottingham. 7 p.m.

Inst. of Structural Engineers: Junior Members.—10, Upper Belgrave-street, S.W.1. Mr. W. H. Laithwaite will open discussion on "The Engineer and the Community." 6.30 p.m.

Royal Inst. of Great Britain.—21, Albemarle-street, W.1. General meeting. 5 p.m.

Royal Soc. of Arts.—John-street, Adelphi, W.C.2. Cantor Lecture, "Geological Aspects of Underground Water Supplies," Dr. Bernard Smith. 8 p.m.

Soc. of Engineers.—At Geological Soc., Burlington House, W.1. "Light Two-stroke Cycle Engines," Mr. G. P. Devaney. 5.30 for 6 p.m.

TUESDAY, DEC. 3RD.

Chadwick Public Lecture.—The Inner Temple Hall, E.C. "Town and County Planning and the Housing Act," Dr. R. C. Maxwell. 8.15 p.m.

Inst. of Automobile Engineers.—At Royal Soc. of Arts, John-street, Adelphi, W.C.2. "The General Question of Supercharging," Mr. Oliver Thornycroft. 7.45 p.m.

Inst. of Civil Engineers.—Great George-street, Westminster, S.W.1. Discussion, "The Energy Output of the Coal Miner," Prof. K. Neville Moss. 6 p.m.

Inst. of Electrical Engineers: London Students.—Visit to the G.P.O. Underground Railway, Mount Pleasant, E.C. 7 p.m.

Inst. of Electrical Engineers: N. Midland Students.—Hotel Metropole, Leeds. Students' lecture, "Modern Street Lighting," Mr. C. C. Paterson. 7.15 p.m.

Inst. of Electrical Engineers: Wireless Section.—Savoy-place, W.C.2. "The Acoustical Design of Broadcasting Studios," Messrs. H. L. Kirke and A. B. Howe. 6 p.m.

Inst. of Engineers and Shipbuilders in Scotland.—39, Elmbank-crescent, Glasgow, C.2. "Electrification of Glasgow District Subway," Mr. W. R. Bruce. 7.30 p.m.

Inst. of Structural Engineers: S. Wales and Monmouthshire Branch.—S. Wales Inst. of Engineers, Park-place, Cardiff. "Cinema Theatres," Mr. A. G. Thompson. 7 p.m.

WEDNESDAY, DEC. 4TH.

Inst. of Civil Engineers.—Great George-street, S.W.1. Informal meeting. Discussion, "Sewerage and Sewage Disposal," introduced by Mr. D. Temple. 6.30 p.m.

Royal Soc. of Arts.—John-street, Adelphi, W.C.2. "Travel in the Stratosphere," Professor G. T. R. Hill. 8 p.m.

The Engineering Soc., City and Guilds College.—South Kensington, S.W.7. "The Renovation of Oil by the Streamline Filter," Professor H. S. Hele-Shaw. 5.15 p.m.

THURSDAY, DEC. 5TH.

Chemical Engineering Group.—Joint meeting with Bristol Group. Visit to Lithographic Printing Works of E. S. and A. Robinson, Ltd., Bedminster, 2.30 p.m. Chemical Department, the University, Woodland-road, Bristol. "Grass Silage and Silos," Messrs. A. W. Ling and W. R. Peel, 6.30 p.m. Hart's Restaurant, Broad-street, Bristol. Informal dinner, 8 p.m.

Inst. of Electrical Engineers.—Savoy-place, W.C.2. "Modern Developments in Railway Signalling," Major L. H. Peter. 5.30 for 6 p.m.

Inst. of Structural Engineers: Yorkshire Branch.—Hotel Metropole, Leeds. Film record of a Welded Building, with a running commentary by Mr. P. L. Roberts. 7 p.m.

FRIDAY, DEC. 6TH.

Inst. of Fuel.—British Industries House, Marble Arch, W.1. Mr. H. A. Humphrey will open discussion, "The Adequacy of Our Fuel Supplies in a Time of National Emergency." 6.30 for 7 p.m.

Inst. of Fuel: E. Midland Section.—Joint meeting with Lincoln Engineering Soc. Technical College, Lincoln. "Sources of Fuel Oils," Dr. A. R. Bowen. 7.30 p.m.

Inst. of Mechanical Engineers.—Storey's-gate, St. James's Park, S.W.1. Informal meeting. 7 p.m.

Inst. of Structural Engineers: Midland Counties Branch.—Leicester. "Rigid Frame Bridges in Reinforced Concrete," Mr. A. P. Mason. 7 p.m.

Inst. of Structural Engineers: Western Counties Branch.—Merchant Venturers' Technical College, Bristol. "Some Aspects of the Theory of Corrosion," Mr. W. H. Dearden. 7.15 p.m.

Junior Inst. of Engineers.—39, Victoria-street, S.W.1. Informal meeting, "Iron: Past and Present, Manufacture and Uses," Mr. R. Lowe. 7.30 p.m.

Physical Soc.—At Imperial College of Science and Technology, S. Kensington, S.W.7. Thomas Young Oration, "Vision in Optical Instruments," Professor Charles Fabry. 5 p.m.

Railway Club.—At Royal Scottish Corporation Hall, Fetter-lane, E.C.4. "How the L.B. and S.C. Railway Kept the Eastbourne Traffic," Rev. R. B. Fellows. 7.30 p.m.

Royal Inst. of Great Britain.—21, Albemarle-street, W.1. Discourse by Mr. F. L. Lucas. 9 p.m.

SATURDAY, DEC. 7TH.

Inst. of Electrical Engineers: London Students.—Visit to Bowater's Paper Mills, Ltd., Northfleet. 2.30 p.m.

MONDAY, DEC. 9TH.

Chartered Surveyors' Inst.—12, Great George-street, S.W.1. "The Restriction of Ribbon Development Act, 1935," Mr. A. T. V. Robinson. 6.30 p.m.

TUESDAY, DEC. 10TH.

Inst. of Automobile Engineers.—At Geisha Café, Hertford-street, Coventry. "Small Car Engines," Mr. L. J. Shorter. 7.30 p.m.

Inst. of Marine Engineers.—85–88, The Minories, E.C.3. "Marine Machinery Failures—Their Causes and Prevention," Dr. S. F. Dorey. 6 p.m.

WEDNESDAY, DEC. 11TH.

Inst. of Electrical Engineers: London Students.—Imperial Hotel, Russell-square, W.C.1. Dance. 8 p.m. to 1 a.m.

Inst. of Engineers-in-Charge.—St. Bride Inst., Bride-lane, E.C.4. Three short papers, "Central Heating and Hot Water Supply," by Gas, Electricity, Coal and Coke respectively, Messrs. R. J. Willsmer, A. Klansner, and H. F. Philliston. 6.30 for 7.30 p.m.

Liverpool Engineering Soc.—9, The Temple, 24, Dale-street, Liverpool. "Large Turbines for Land Power Stations," Mr. L. S. Robson. 6.30 p.m.

Royal Soc. of Arts.—John-street, Adelphi, W.C.2. "The Organisation of Transport, with Special Reference to London Passenger Transport Board," Mr. Frank Pick. 8 p.m.

THURSDAY, DEC. 12TH.

Inst. of Automobile Engineers.—Merchant Venturers' Technical College, Bristol. "The General Question of Supercharging," Mr. Oliver Thornycroft. 7 p.m.

Inst. of Civil Engineers: Birmingham and District Assoc.—Queen's Hotel, Birmingham. Annual dinner. 6.30 for 7 p.m.

Inst. of Fuel.—At Chemical Soc., Burlington House, Piccadilly, W.1. "Production of Lubrication Oil from Coal Products," Professor Alfred W. Nash. 6 p.m.

Inst. of Marine Engineers: Junior Section.—85–88, The Minories, E.C.3. Film Display: (1) The Building and Launching of the Cunard White Star Liner "Queen Mary"; (2) Southampton Docks Extensions; (3) The All-welded Ship "Peter G. Campbell." 7 p.m.

Inst. of Structural Engineers.—10, Upper Belgrave-street, S.W.1. "Some Bridge and Foundation Problems," Mr. Leslie Turner. 6.30 p.m.

FRIDAY, DEC. 13TH.

Belfast Assoc. of Engineers.—Queen's Hotel, Belfast. Smoking concert. 8 p.m.

Inst. of Electrical Engineers: London Students.—Savoy-place, W.C.2. "The Students'" Lecture, "Developments in the Materials of Construction of Electrical Plant and Apparatus—Magnetic, Insulating, Conducting, and Mechanical," Mr. A. P. M. Fleming. 6.30 for 7 p.m.

Inst. of Mechanical Engineers.—Storey's-gate, St. James's Park, S.W.1. "Damping Influences in Torsional Oscillation," Dr. J. F. Shannon. 6 p.m.

Junior Inst. of Engineers.—At Royal Soc. of Arts, John-street, W.C.2. Presidential address, "Coal, Power and Smoke," Sir Frank E. Smith. 7.30 p.m.

Inst. of Fuel: East Midland Section.—Joint meeting with Soc. of Chemical Industry. University College, Nottingham. "Compressed Gas as a Fuel for Motor Transport," Mr. R. Cook. 7 p.m.

FRIDAY AND SATURDAY, DEC. 13TH AND 14TH.

Borough Polytechnic.—Borough-road, S.E.1. Exhibition of Students' Work. Friday, 6 to 9 p.m.; Saturday, 4 to 9.30 p.m.

SATURDAY, DEC. 14TH.

Inst. of Marine Engineers: Junior Section.—85–88, The Minories, E.C.3. Dance. 7.30 to 11.15 p.m.

Manchester Assoc. of Engineers.—At College of Technology, Manchester. Conversazione and dance. 6.45 p.m. to 11.30 p.m.

MONDAY, DEC. 16TH.

Inst. of Automobile Engineers.—At James Watt Memorial Inst., Birmingham. "The General Question of Supercharging," Mr. Oliver Thornycroft. 7.30 p.m.

Inst. of Automobile Engineers.—At Inst. of Engineers and Shipbuilders in Scotland, 39, Elmbank-crescent, Glasgow. "Small Car Engines," Mr. L. J. Shorter. 7.45 p.m.

TUESDAY, DEC. 17TH.

Inst. of Automobile Engineers.—The Cavendish Café, Cornmarket, Derby. "The General Question of Supercharging," Mr. Oliver Thornycroft. 7.30 p.m.

Inst. of Automobile Engineers.—The George Hotel, Luton. "Inspection and Quality Control," Mr. M. C. Park. 7.30 p.m.

Inst. of Structural Engineers: Scottish Branch.—University Old College, Edinburgh. "Bridges," Mr. J. Shannon. 7.15 p.m.